Morgan Conservation Park Lagoons Wetland Management Plan

Review and Update 2012

Department of Environment, Water and Natural Resources (Berri)

Cite as:

Ireland, L. J. (2012) Morgan Conservation Park Wetland Management Plan Review and Update 2012, Department of Environment, Water and Natural Resources, Berri, South Australia.

Acknowledgements

This wetland management plan has been developed with support from a number of people from the Department of Environment, Water and Natural Resources.

Government of South Australia
Department of Environment, Water and Natural Resources

Funding was provided by Department of Environment, Water and Natural Resources - Riverine Recovery Project.

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Note

This wetland management plan encompasses the floodplain and wetland areas of Morgan Conservation Park Lagoons. Within the text 'MORGAN Cp Lagoon' refers to the wetland-floodplain complex as a whole, where 'wetland' refers to the low-lying wetland areas and 'floodplain' refers to the areas of higher elevation inundated during flood events.

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Acronyms and abbreviations

AHD	Australian Height Datum
AWE	Australian Water Environments
CAMBA	China-Australia Migratory Bird Agreement
CEWH	Commonwealth Environmental Water Holder
DIWA	Directory of Important Wetlands (South Australia)
DO	Dissolved Oxygen
EC	Electrical Conductivity
EPBC	Environmental Protection and Biodiversity and Conservation
FIM	Flood Inundation Model
ha	Hectare
JAMBA	Japan-Australia Migratory Bird Agreement
km	Kilometers
m	Meters
ML	Megalitres
M.O.U.	Memorandum of Understanding
NPW	National Parks and Wildlife
NRM	Natural Resources Management
NTU	Nephelometric Turbidity Units
pH	(p)otential of (H)ydrogen
RMWBS	River Murray Wetlands Baseline Survey
ROKAMBA	Republic of Korea Migratory Bird Agreement
RWLAP	Riverland West Landcare
SA	South Australia
SA MDB NRM Board	South Australian Murray-Darling Basin Natural Resources Management Board
SARDI	South Australian Research and Development Institute
WMP	Wetland Management Plan

Introduction

Morgan Conservation Park Lagoons (henceforth known as Morgan CP Lagoon) is located approximately 1 km from the township of Morgan and is situated on the eastern bank of the River Murray. This wetland provides important habitat and resources for a range of biota, including species of conservation significance from several taxa.

A range of issues Morgan CP, including altered river hydrology (particularly changes in flood frequency, duration and timing), habitat loss and/or alteration and the impacts of introduced animals and plants such as Common Carp (*Cyprinus carpio*) and Golden Dodder (*Cuscuta campestris*).

This management plan, which is an update of the original plan written in 1999 (Jensen *et al*, 1999), aims to support the site's recovery and establish a healthy and resilient wetland supporting a range of native biota.

To achieve this aim the following objectives have been identified:

1. **Re-store the semi-permanent nature of Morgan CP Lagoon.** Using the inlet structure, water levels in Morgan Lagoon have been actively managed to mimic a somewhat natural hydrology regime (wetting and drying). This has had a positive impact on the environmental values of the wetland.
2. **Maintain or improve the diversity and area of vegetation including littoral and fringing zones and submerged and emergent aquatic vegetation.** Since 2007, 41 species of plants have been recorded at Morgan CP Lagoon during wet and dry phases
3. **Maintain or improve the condition of River Red Gums across a range of age-classes, particularly regenerating stands and mature, hollow bearing trees.** The River Red Gums are of particular importance as they occur in both mature and regenerating stands. Bands of mature River Red Gums with a high conservation value have been identified along the channel at the end of the Southern Lagoon. In addition, the Regent Parrot (*Polytelis anthopeplus monarchoides*), which is listed as 'Vulnerable' under the South Australian *National Parks and Wildlife Act 1972*, breeds annually here in tree hollows and regularly inhabits the site throughout the year. This species relies on suitable tree hollows for nesting. Future management of Morgan CP Lagoon should consider the importance of healthy stands of several age classes of regenerating River Red Gum, including hollow bearing trees with the capacity to provide suitable nest sites for Regent Parrots.
4. **Maintain or improve the abundance and diversity of waterbird species foraging and breeding.** Since 2007, thirty-six species of water birds have been recorded at Morgan CP Lagoon including four species of conservation significance; the Freckled Duck (*Stictonetta naevosa*) is listed as 'Vulnerable' and the Glossy Ibis (*Plegadis falcinellus*), Latham's Snipe (*Gallinago* hardwickii), Australasian Shoveler (*Anas rhynchotis*), Musk Duck (*Biziura lobata*),Darter (*Anhinga novaehollandidae*) and Blue-billed Duck (*Oxyura australis*) are listed as 'Rare' under the South Australian *National Parks and Wildlife Act 1972*.
5. **Maintain or improve the diversity and abundance of frog species.** Since 2007, six species of frogs have been recorded within Morgan Conservation Park including the listed Southern Bell Frog (*Litoria raniformis*), which has been recorded in moderate to high numbers.
6. **Maintain or improve the diversity and abundance of native fish and reduce the abundance of introduced fish species.** Since 2007, nine native species of fish have been captured at Morgan Conservation Park including one species of conservation significance, the Freshwater Catfish (*Tandanus tandanus*).
7. **Promote the establishment of Slender Knotweed (*Persicaria decipiens*) on the lagoon dry bed at least every second dry event.**

On-going monitoring will inform the management of the wetland and enable progress against the plan's objectives to be evaluated.

Wetland description

The following section provides information on the location, physical characteristics and hydrology of Morgan Conservation Park Lagoon.

Location

Morgan Conservation Park is located approximately 1 km from the township of Morgan and is situated on the eastern bank of the River Murray (Figure 1). This wetland complex consists of a mixture of permanent and temporary wetlands. The Cadell Road causeway runs east west across the area of the Morgan Ferry and bisects the main lagoon (Jensen *et al*. 1999). These two sections are referred to as the North Lagoon and South Lagoon. Three concrete pipes underneath the causeway connect the two lagoons. The closest neighbouring wetlands are Morgan East and Northwest Bend approximately 2 km to the east.

Table 1: Location information for Morgan Conservation Park

Wetland coordinates	AMG Coordinates (Zone 54) 0378674 E 6232984 N
Description of location	The Morgan Conservation Park Lagoons are located 100 to 200 m from the eastern bank of the River Murray less than 1 km from the centre of the township of Morgan.
Floodplain/wetland complex name	Morgan Conservation Park (Atlas number S0122)
Lock reach	Between Locks 1 and 2
NRM Group area	Ranges to River
Local Action Planning area	Riverland West Landcare
Council area	Mid-Murray Council

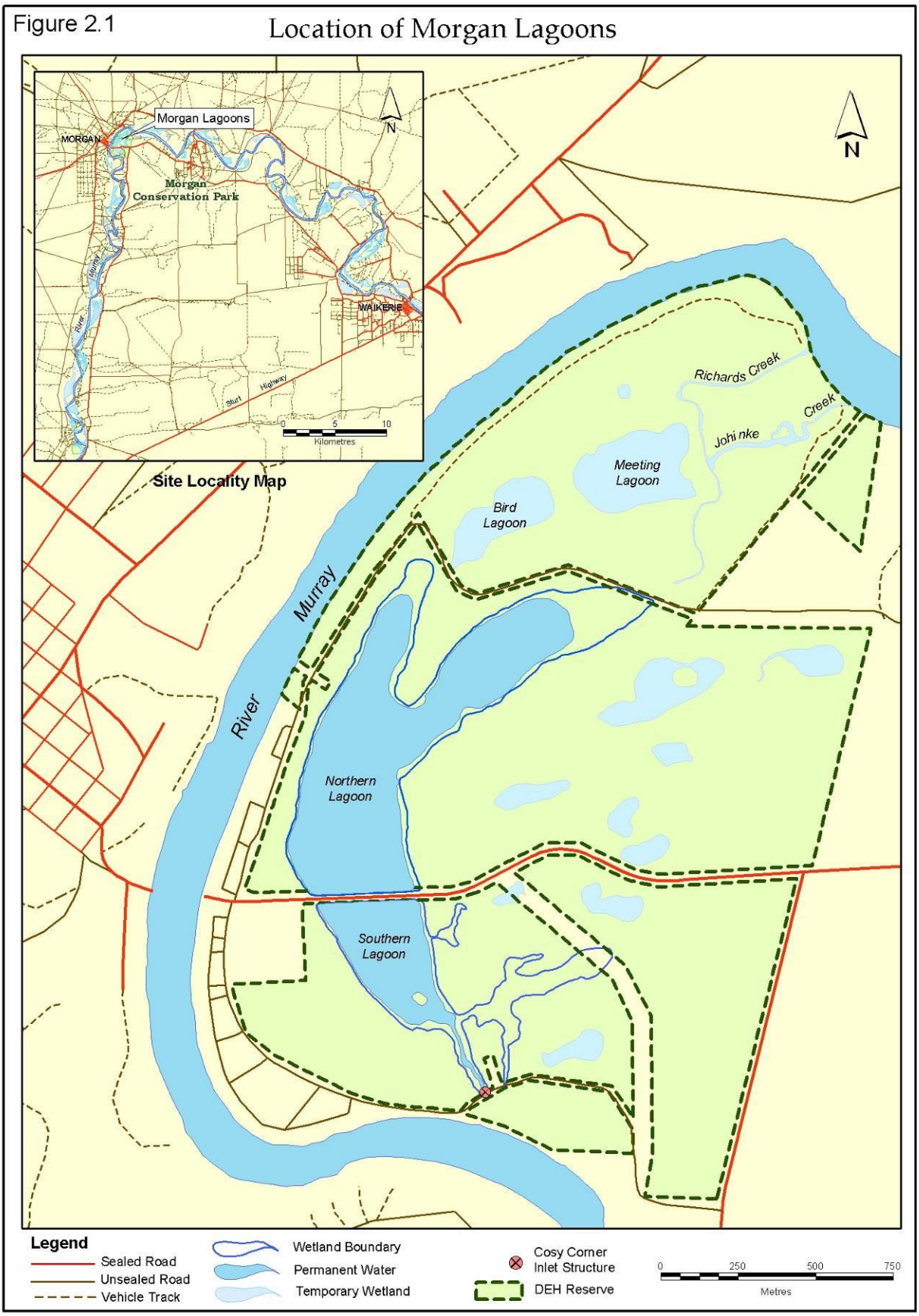

Figure 1: Location map of Morgan Conservation Park

Current management arrangements

The current management arrangements for the site are as follows (Table 2).

Table 2: Management details for Morgan Conservation Park.

Land tenure	Conservation Park – managed in accordance with the *National Parks and Wildlife Act, 1972*.
LAP Group	Riverland West Landcare
Name of organisation that will physically operate structures	Department for Environment, Water and Natural Resources (DEWNR)
Monitoring arrangements	Department for Environment, Water and Natural Resources (DEWNR) – Wetland Ecologist

Physical Characteristics

Physical characteristics of Morgan Conservation Park are included in the following table (Table 3).

Table 3: Physical characteristics of Morgan CP Lagoon

Name of wetland (and GIS polygon if different)	AUS wetland number	Coordinates	Wetland type	Pool level (m AHD)	Surface area (ha) at pool	Vol at pool (ML)	Depth at pool (ave)	Depth at pool (max)
Morgan CP Lagoon	S0122	378674 E 6232984 N	Temporary	3.2	45.7	365.6	0.8 m	~1.55 m

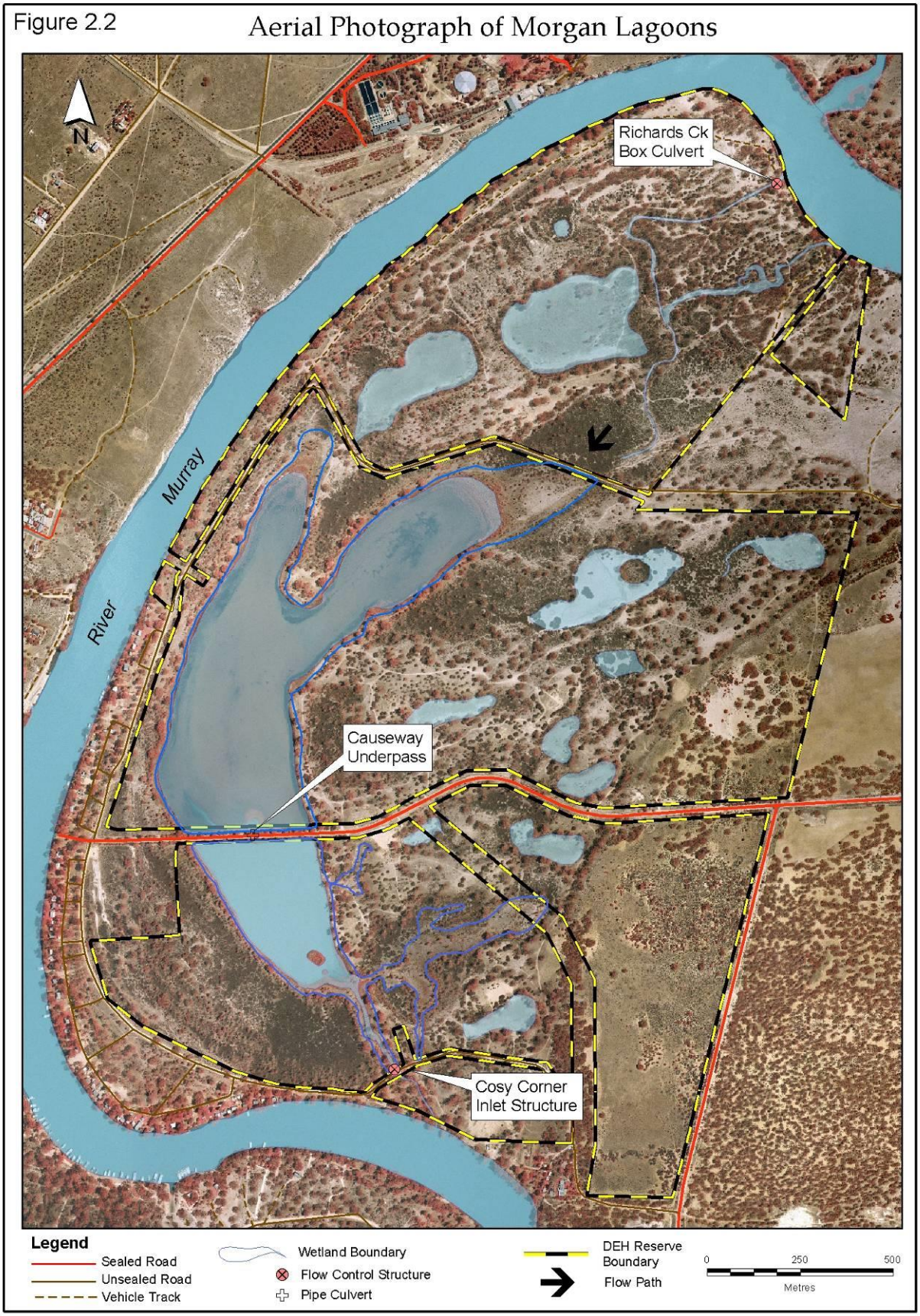

Figure 2: Aerial photograph of Morgan Conservation Park detailing the location of environmental structures.

Wetland Hydrology

Morgan Conservation Park Lagoons consists of a mixture of permanent and temporary wetlands.

Natural Hydrology

Prior to River regulation, Morgan Lagoon reacted in response to the higher degree of seasonal and annual variation in the River Murray's flow, which triggered the drying, and shrinking of the wetlands. Occasionally the river flow stopped completely leaving only a series of pools along the riverbed (Close, 1990). When the new Morgan to Cadell causeway was constructed during 1963/64 Morgan Lagoon was split into two sections that are now referred to as the Northern and Southern Lagoons of Morgan Lagoon.

Current Hydrology

The hydrology of Morgan Lagoon is related directly to the flow levels of the River Murray as it has a direct flow connection to the main River Murray channel. The bed height of Morgan Lagoon at its lowest point is 2.33 m AHD compared to the River pool level between Lock 1 and Lock 2 of approximately 3.2 m AHD. In the absence of hydrological management the Lagoon was virtually permanent in recent times, having dried only once in the ten years spanning 1982 to 1992 (NPWS 1992) and once in 1998 before the flow control structure was installed in 2000 at Cosy Corner Inlet to introduce a dry phase. It seems that the Cosy Corner inlet channel was more a flow path than a channel prior to 2000 that would silt or block up with Cumbungi between large flood events thus enabling Morgan Lagoon to irregularly dry during low river flow periods.

Morgan Lagoon and the surrounding temporary lagoons are filled via a series of temporary creeks. Different River flows are required commence the inundation of these creeks, the first creek being flowing is Richards Creek which commences to flow at approximately 24 000 ML/day, however water does not reach the Morgan Lagoon through the upstream flow path until flows exceed ~58,000 ML/day (Jensen *et al.,* 1999). Under current conditions, flows of ~60,000 ML/day are only experienced approximately 3.5 in 10 years (modeled current system (BIGMOD, 2011) in comparison with approximately 7 in 10 years under modeled historical conditions (BIGMOD, 2011).

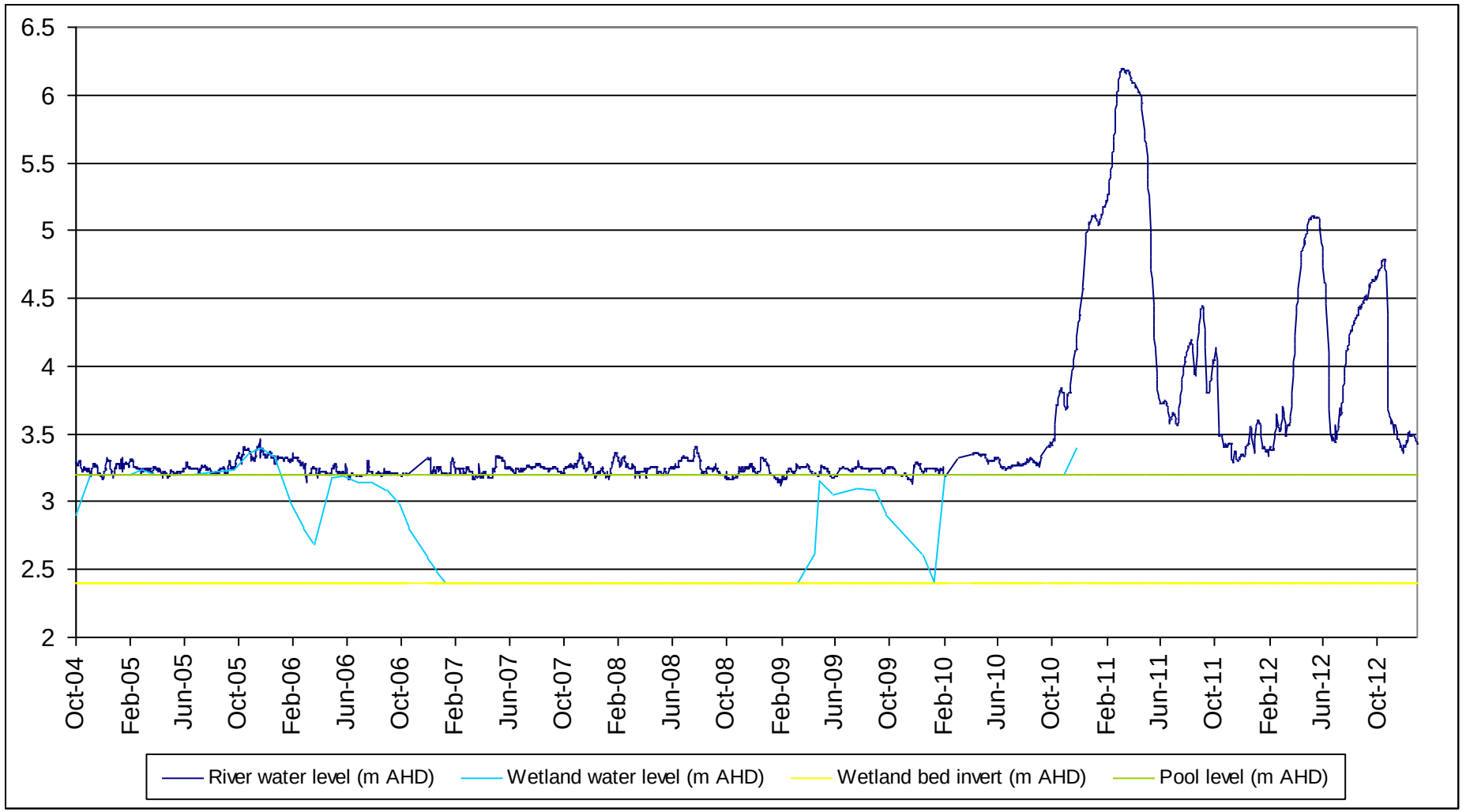

Figure 3: Actual hydrological regime of Morgan CP Lagoon relative to River Murray levels.

Structures

Morgan Lagoon water level can be manipulated by the existing flow control structure. The remaining wetlands within Morgan Conservation Park are temporary wetlands that fill at a flows ranging from 58 000 ML/day to 105 000 ML/day (Jensen *et al*., 1999).

Table 4: Details of structures at Morgan Conservation Park.

Name of structure	Description of location of structure	GPS location	Structure type	Invert level (m AHD)	Crest height or top of structure (m AHD)	Corresponding flow relating to crest height
Cosy Corner Inlet structure	Located on flow channel between Main River and Southern Lagoon	378540 E 6232124 N	Two 900 mm x 600 mm concrete box culverts with adult carp exclusion screens and aluminium stop logs	2.87	4.29	58 000 ML/day.
Morgan to Cadell Causeway underpass	Located on the causeway underpass between Northern and Southern Lagoons	378166 E 6232740 N	Three 900 mm concrete pipes with aluminium stop logs located on Southern Lagoon side	3.09		
Richards Creek box culvert	Located on flow channel between Main River and Northern Lagoon. At the Main River end of flow channel	379565 E 6234490 N	Three 1,200 mm x 1,200 mm bay, concrete box culverts The structure is not to a standard that would allow hydrological control of the creek. The structure has been abandoned	3.6		

Figure 4: Cosy Corner inlet structure

Figure 5: Morgan to Cadell causeway underpass

Figure 6: Richard's Creek box culvert

Wetland Values

Environmental values

Morgan Conservation Park provides critical habitat for a range biota of conservation significance.

Table 5: Flora species of conservation significance recorded at Morgan CP since 2004

Common name	Scientific name	Conservation status / significance
Prickly bottlebrush	*Callistamon brachyandrus*	SA Rare

A range of fauna species of conservation significance has also been recorded.

Table 6: Fauna species of conservation significance recorded at Morgan CP since 2003.

Common name	Scientific name	Conservation status / significance
Birds		
Australasian Darter	*Anhinga novaehollandiae*	SA NPW - Rare
Caspian Tern	*Hydroprogne caspia (Sterna caspia)*	EPBC - Migratory
Great Egret	*Egretta alba*	CAMBA, JAMBA
Glossy Ibis	*Plegadis falcinellus*	SA NPW – Rare, CAMBA
Freckled Duck	*Stictonetta naevosa*	SA NPW – Vulnerable
Australasian Shoveler	*Anas rhynchotis*	SA NPW - Rare
Blue-billed Duck	*Oxyura australis*	SA NPW - Rare
Musk Duck	*Biziura lobata*	SA NPW - Rare
Buff-banded Rail	*Rallus philippensis*	CAMBA, JAMBA
Sharp-tailed Sandpiper	*Calidris acuminata*	CAMBA, JAMBA, ROKAMBA
Latham's Snipe	*Gallinago hardwickii*	SA NPW – Rare, CAMBA, JAMBA, ROKAMBA
Regent Parrot	*Polytelis anthopeplus monarchoides*	EPBC – Vulnerable, SA NPW - Vulnerable
Fish		
Freshwater Catfish	*Tandanus tandanus*	SA – Endangered (Hammer, et al., 2009)
Golden Perch	*Macquaria ambigua ambigua*	SA – 'near threatened' (Hammer, et al., 2009)
Unspecked Hardyhead	*Craterocephalusstercusmuscarumfulvus*	SA – 'near threatened' (Hammer, et al., 2009)
Amphibians		
Southern Bell Frog	*Litoria raniformis*	EPBC - Vulnerable SA NPW - Vulnerable
Reptiles		
Carpet Python	*Morelia spilota metcalfei*	SA NPW - Vulnerable

Aboriginal values

The Ngaiawang aboriginal tribe occupied the Morgan area (NPWS 1992). No archaeological survey work has been done in the Park, but the region is known to be rich in sites and artefacts.

Social values

With its proximity to Adelaide and location on the banks of the River Murray, the Conservation Park is an area of high recreation use. The popularity of the park is highlighted by the seasonally high visitation rates and large number of holiday shacks situated along Holiday Lagoon.

The River and the areas in proximity are popular sites for recreational activities such as launching and mooring speedboats, water skiing, swimming and fishing, whilst the areas around the main Lagoon are popular for activities such as yabbying, camping, horse riding and the use of off-road vehicles, including trail bikes. Recreational use tends to be short-term and highly seasonal coinciding with school holidays and long weekends with the majority of visitors originating from within the region or from Adelaide (NPWS, 1992).

The Morgan CP Lagoon lies wholly within a conservation park that enjoys a high visitation rate and consequently has an extremely high potential value for visitor education, particularly as a demonstration site for effective hydrological management within a wetland. Easy access to the Lagoon and visual evidence of environmental responses to hydrological management combine to make Morgan Lagoon a suitable tour site, whilst the site itself is enhanced by the presence of regenerating River Red Gums and increased numbers of aquatic organisms during wet-phases. On re-flooding, the drying Lagoon bed and the resultant re-growth of terrestrial plants provide water birds with an important food source. Also visible are the particular structures used in wetland management such as flow-control gates and large fish exclusion screens.

There is high potential for community involvement in the wetland management of Morgan Lagoon and groups have already been involved. Volunteers from the Murray Darling Association have collected biological data for use in the preparation of this management plan, and the local Primary School has provided sets of macro-invertebrate data for inclusion as well.

Management History

Historical management and use

Morgan CP Lagoon is located entirely within the Morgan Conservation Park, an area of 363 ha. Old Murbko Road and a river shack community in the southwest corner, the River Murray in the northwest corner and the Murbko Road to the east border this park.

The Morgan Conservation Park is managed by the South Australian Department of Environment and Natural Resources in accordance with the *National Parks and Wildlife Act 1972*. Under this act Conservation Parks are lands that should be protected or preserved to conserve the flora, fauna and natural or historic features they contain. This park was declared in 1979, primarily to protect its wetlands and River Red Gum woodland.
The primary land and water use at Morgan Conservation Park is conservation and recreation. A number of land use activities occur adjacent to the Park including include rural urban, hobby farming and dry-land farming (stock and grain).

Previous management plans

The document is a review and update of the wetland management plan written in 1999. The key element of the previous wetland management plan was to restore the flooding frequency and duration to Morgan CP similar to what would have been expected prior to river regulation (Jensen et al, 1999).

On 1st July 2002, the incumbent Minister for the Environment and Conservation at the time adopted the Water Allocation Plan for the River Murray Prescribed Watercourse. South Australia was granted entitlement flows of 1850 GL per annum, of which 200 GL was allocated for wetlands located along the River Murray. In order to obtain a water allocation, wetland management plans are required for submission in order to meet State Government policy requirements.

Hydrological management log

Details of hydrological management actions are presented in Table 7 below.

Table 7: Management details for Morgan CP Lagoon.

Date	Management Stage	Management Action
01 September, 2004	Filling	Inlet structure opened
23 December, 2005	Drawing down	Inlet structure closed
17 April, 2006	Filling	Inlet structure opened due to structure being vandalised
02 May, 2006	Drawing down	Inlet structure closed
20 December, 2006	Dry	
16 March, 2009	Filling	Inlet structure opened
28 April, 2009	Drawing down	Inlet structure closed
14 December, 2009	Dry	
13 January, 2010	Filling	Inlet structure opened
03 February, 2012	Drawing down	Inlet structure closed
28 March, 2012	Filling	Inlet structure opened
14 December, 2009	Dry	
13 January, 2010	Filling	Inlet structure opened
01 August, 2011	Drawing down	Inlet structure closed – still leaking water due to high flows
26 October, 2011	Filling	Inlet structure closed
03 February, 2012	Drawing down	Inlet structure closed
28 March, 2012	Filling	Inlet structure opened

Summary of wetland monitoring data

A number of ecological parameters have been monitored at Morgan CP Lagoon since 2003. DEWNR Berri wetland staff (DEWNR) have conducted the majority of monitoring at the site. Currently, several parameters are monitored and include:

- Groundwater: depth (m AHD) and Electrical Conductivity (EC) (µS/cm).
- Surface Water: Electrical Conductivity (EC) (µS/cm), pH (units), Turbidity (NTU) and Dissolved Oxygen (mg/L) have been collected since 2009.
- Vegetation (Species presence, absence and frequency).
- Birds (Species and Abundance) collected since 2003.
- Fish (Species and Abundance).
- Frogs (Species and Abundance).
- Other incidental ecological observations including tadpoles, turtles, reptiles and aquatic macroinvertebrates.

Morgan CP has four water quality sites and water quality is monitored monthly at each of these sites along with waterbird point-counts. In addition, frogs and fish surveys are also conducted seasonally at these sites.

Physical Parameters

Groundwater

A network of four piezometers was installed in the Northern Lagoon and three in the Southern Lagoon. In May 2004, five months after dry phase commenced, water samples from these test wells revealed low water salinity levels ranging between 2170 to 2490 EC (µS/cm) in the Northern Lagoon, while in the Southern Lagoon levels ranged between 1820 µS/cm under the lagoon bed to 9050 µS/cm further up the bank. By August 2004, eight months after the dry phase was introduced, salinity levels had not changed significantly (See Table 8).

In the Northern Lagoon the highest groundwater levels were recorded further up the bank and the lowest levels were recorded under the Lagoon bed. Generally ground water levels slowly increased during the winter months of 2004 when the Lagoon was dry. Immediately after the Lagoon was inundated in September 2004, the Southern Lagoon edge ground water level readings indicated a rapid response to wetland inundation. Groundwater levels increased over time, which suggests a high degree of hydraulic connectivity between surface water and groundwater. This will help maintain a freshwater lens in the wetland. Further monitoring is needed to confirm the significant link between groundwater response and both winter rainfall and wetland inundation.

During 2008, groundwater monitoring was undertaken on two occasions while the lagoon was disconnected from the River for drought water savings for critical human needs. During the monitoring in early 2008, three of the seven piezometers were dry and one was destroyed. Of the remaining three piezometers EC levels ranged from 2170 µS/cm to 3110 µS/cm and groundwater levels did not vary significantly (Table 8). Monitoring was again undertaken late 2008 both salinity and groundwater levels varied little (Table 8).

Table 8: Ground water levels and salinities for seven piezometers at Morgan Lagoon during 2004 and 2008.

Date	Site	Water height (m) AHD	Conductivity (EC)
11/05/04	Northern A (Lagoon floor)	1.10	2400
	Northern B (Lagoon edge)	1.65	2490
	Northern C (Adjacent floodplain)	1.69	2400

	Northern D (Adjacent floodplain)	1.7	2170
	Southern A (Lagoon floor)	3.69	2450
	Southern B (Lagoon edge)	1.62	1820
	Southern C (Adjacent floodplain)	Dry	Dry
17/08/04	Northern A (Lagoon floor)	1.78	2000
	Northern B (Lagoon edge)	1.83	2380
	Northern C (Adjacent floodplain)	1.82	
	Northern D (Adjacent floodplain)	1.85	2110
	Southern A (Lagoon floor)	2.25	2380
	Southern B (lagoon edge)	2.35	2210
	Southern C (Adjacent floodplain)	0.43	9650
22/02/08	Northern A (Lagoon floor)	1.37	3110
	Northern B (Lagoon edge)	Dry	Dry
	Northern C (Adjacent floodplain)	Destroyed	Destroyed
	Northern D (Adjacent floodplain)	Dry	Dry
	Southern A (Lagoon floor)	1.56	2440
	Southern B (lagoon edge)	1.76	2170
	Southern C (Adjacent floodplain)	Dry	Dry
11/11/08	Northern A (Lagoon floor)	1.57	3520
	Northern B (Lagoon edge)	Dry	Dry
	Northern C (Adjacent floodplain)	Destroyed	Destroyed
	Northern D (Adjacent floodplain)	1.66	8020
	Southern A (Lagoon floor)	1.54	2610
	Southern B (lagoon edge)	1.9	5090
	Southern C (Adjacent floodplain)	Dry	Dry

Surface Water

Water quality is an important indicator for managing and maintaining aquatic species, both fauna and flora, and is a relatively complex combination of chemical and biological interactions, which change over short timeframes (e.g. diurnally) and longer timeframes (e.g. seasonal changes).

The surface water quality parameters presented here are measured at two sites (Site A and Site B) on Morgan CP at monthly intervals, where possible. Surface water quality has been measured since October 2004 and includes the following parameters:

- Salinity (Electrical conductivity)(µS/cm)
- pH (units)
- Turbidity (NTU)
- Dissolved Oxygen (mg/L)

Results from monitoring since 2006 are presented in the following figures (Figure 7 to Figure 10). Some sites were not surveyed due to inaccessibility during the flood event of 2010-2011 or as they became dry between 2007 and 2009.

Physical and chemical variations in the surface water quality occur as a result of disturbance events such as droughts and floods, are determined by the flow of groundwater, the surface topology, geology of the wetland bed and banks and management of the wetland (Tiner, 1999; Mitsch & Gosselink, 2007; Haslam, 2003; Tucker, 2003).

(Note: different scales are used for each figure).

Surface Water Electrical Conductivity (µS/cm)

Wetland salinity levels vary according to wetland size, shape and complexity as well as the level of salt found in the sediments and inputs from saline groundwater. High EC levels are most likely influenced by groundwater intrusion and evaporation, which increases salinity concentrations as water levels recede.

EC levels across the four monitoring sites have ranged between 130 µS/cm (August 2011, MCPWQ2) and 3110 µS/cm (November 2006, MCPWQ2). EC was highest during late 2006 owing to the lagoon being nearly dry. This result is to be expected due to high levels of evaporation which increases salinity concentrations as water levels recede. There are some differences in EC between the North (MCPWQ1 and MCPWQ2) and South (MCPWQ3 and MCPWQ4) lagoons, the South lagoon recording lower EC levels owing to the south lagoon being connected to the River and water then flowing into the northern end of the lagoon.

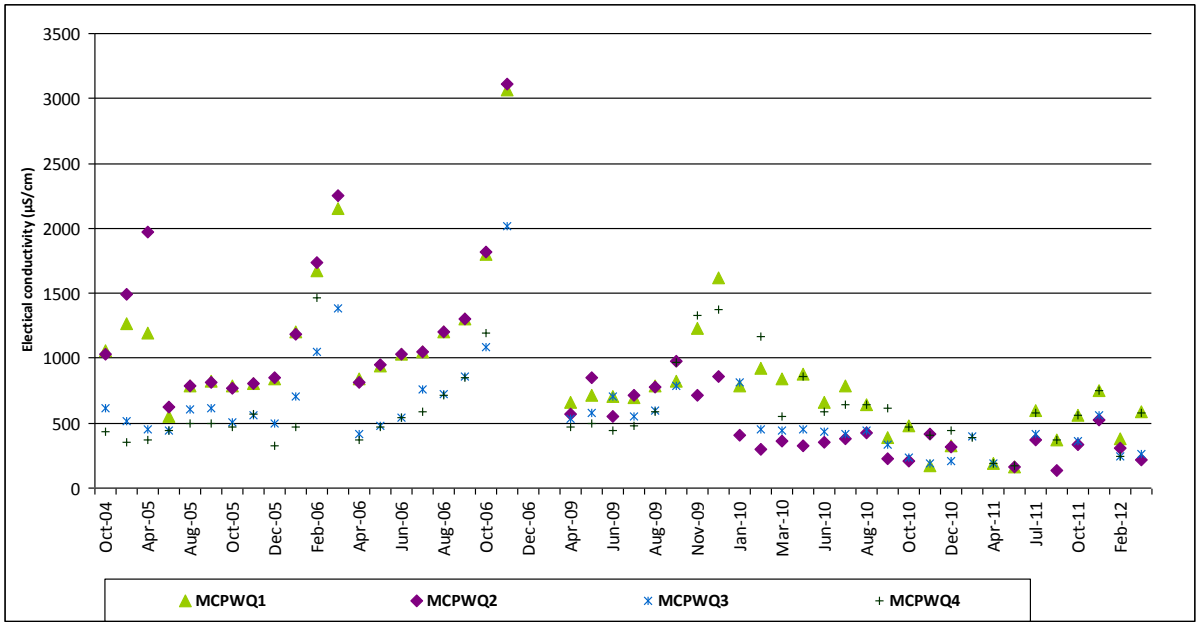

Figure 7: Surface water electrical conductivity (µS/cm), Morgan CP Lagoon, 2004 – 2012.

Surface Water pH (units)

Surface water pH in Morgan CP Lagoon ranged between 6.05 and 10.2 pH (units) (Figure 8). The lowest pH was recorded at 6.05 at site MCPWQ2 in July 2011, while the highest pH was recorded at 10.2 at sites MCPWQ3 and MCPWQ4 in January 2006.
Typically surface water pH falls between 6-9 pH and any levels outside of this range may indicate unusual processes occurring within the wetland (Baldwin, et al., 2005). Generally however, surface water pH did not consistently fall outside of these levels. Higher surface water pH may be recorded as a result of abundant aquatic macrophyte growth (Cronk & Fennessy, 2001). Aquatic macrophytes remove carbon dioxide (CO_2) from the water column through the process of photosynthesis, which results in elevated surface water pH levels being observed, particularly in summer when photosynthesis rates are generally higher than in winter (Cronk & Fennessy, 2001; Berezina, 2001; Baldwin, et al., 2005). Additionally, surface water pH may be increased through some bacteria processes, such as dentrification or accelerated algal growth (Baldwin, et al., 2005).

Lower surface water pH may be caused by high organic loads, bacteria processes (such as nitrification) or oxidisation of sulfidic sediments (Baldwin, et al., 2005).

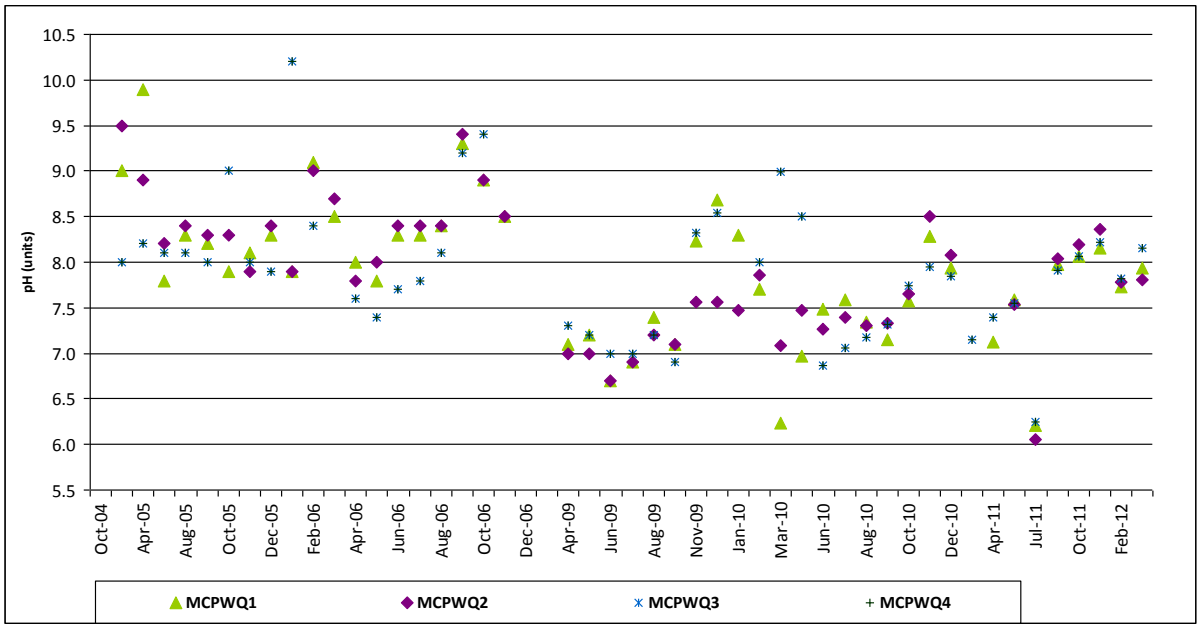

Figure 8: Surface water pH (units), Morgan CP Lagoon, 2004 – 2012.

Surface Water Turbidity (NTU)

Turbidity levels in Morgan CP Lagoon ranged between 5 and 418 (NTU) (Figure 9). Low turbidity levels have been recorded periodically across all four monitoring sites. In particular, monthly surveys conducted between May 2009 and July 2009 recorded turbidity levels of 5 NTU at each of the monitoring sites. These surveys occurred just after the wetland was refilled in April 2009. Prior to this the wetland had been dry since December 2006. Consolidating wetland bed sediments through drying is recognised as a factor resulting in lower turbidity readings being recorded upon the re-filling of the wetland (Tucker, 2003) although this is also dependent upon the turbidity levels of water from the River. Additionally, Common carp (*Cyprinus carpio*) may have been present in low abundances after the wetland was refilled. The bioturbation activities of Common carp, resulting in the resuspension of sediments is also likely to be a cause of increased turbidity levels in surface waters in the River Murray (Biolotta & Brazier, 2008; Tucker, 2003). Low surface water turbidity may also be a result of reduced water circulation through the wetland, particularly as water levels remained relatively stable during this period (Tucker, 2003).

The highest turbidity was observed in November 2009 at site MCPWQ2 (418 NTU). However, other sites surveyed at this time exhibited lower turbidity levels (<100 NTU). This anomaly may have been caused by wetland bed sediments being disturbed through monitoring practices. Generally, turbidity was higher during the period between late 2010 and 2012. High river flows at this time caused overbank flooding in the wetland and higher turbidity may have been a result of increased water circulation (Tucker, 2003). Higher turbidity

readings may also be a result of wind-seiches and given the shallow nature of the wetland, this is likely to be a leading cause of higher turbidity readings (Tucker, 2003). As stated above, Common Carp may also have a significant influence on turbidity levels.

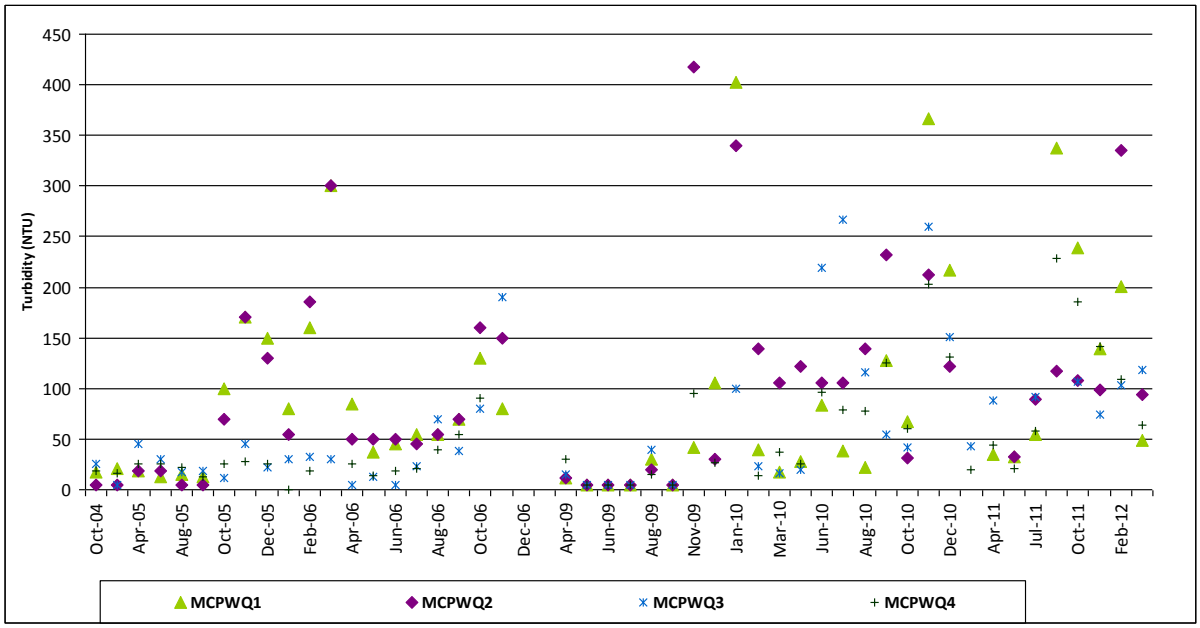

Figure 9: Surface water turbidity (NTU), Morgan CP Lagoon, 2004 – 2012.

Surface Water Dissolved Oxygen (mg/L)

Dissolved oxygen is a very important determinant of wetland biota survival (Baldwin, et al., 2005; Tucker, 2003). Dissolved oxygen is a highly variable parameter which changes according to the season and the time of day, being lower in summer than winter, and higher in the afternoon than in the morning. It varies with proximity to the surface, or bottom of a water body, with DO levels being higher near the surface than near the bottom. DO levels typically fall between 7-10 mg/L depending on surface water temperature (Baldwin, *et al*., 2005). Low DO, that is dissolved oxygen less than 5 mg/L, has the ability to cause stress and impede normal functions and functioning in the organisms body, and may lead to the mortality of aquatic organisms (Baldwin, *et al*., 2005; Tucker, 2003). As such, persistently low DO levels should be a cause for concern. Low dissolved oxygen levels may be due to microorganism activity which acts to breakdown organic matter within the wetland, reducing dissolved oxygen availability (Tucker, 2003). High dissolved oxygen levels may occur as a result of wind-assisted mixing as well as generated by photosynthesising algae in the wetland (SKM, 2004; Tucker, 2003). Spot measurements are not particularly useful in adequately interpreting DO results, where a full diurnal range of DO concentrations is required before data can properly be interpreted.

Dissolved oxygen has been monitored at Morgan CP Lagoon since 2009. Surface water DO levels ranged between 21.77 mg/L (MCPWQ4, August 2011) and 3.27 mg/L (MCPWQ1, March 2010). Typically, DO has fluctuated within a band between approximately 5 and 10 mg/L. High DO levels were observed in August 2011, where DO levels greater than 20 mg/L were recorded at two monitoring sites.

Low DO levels (<5 mg/L) were observed at all four sites in February and March 2012. Continuation of current monitoring programs will inform management if these low levels persist in the system. Overall, surface water DO was not consistently recorded below 5 mg/L and should therefore not be considered to be a key management concern.

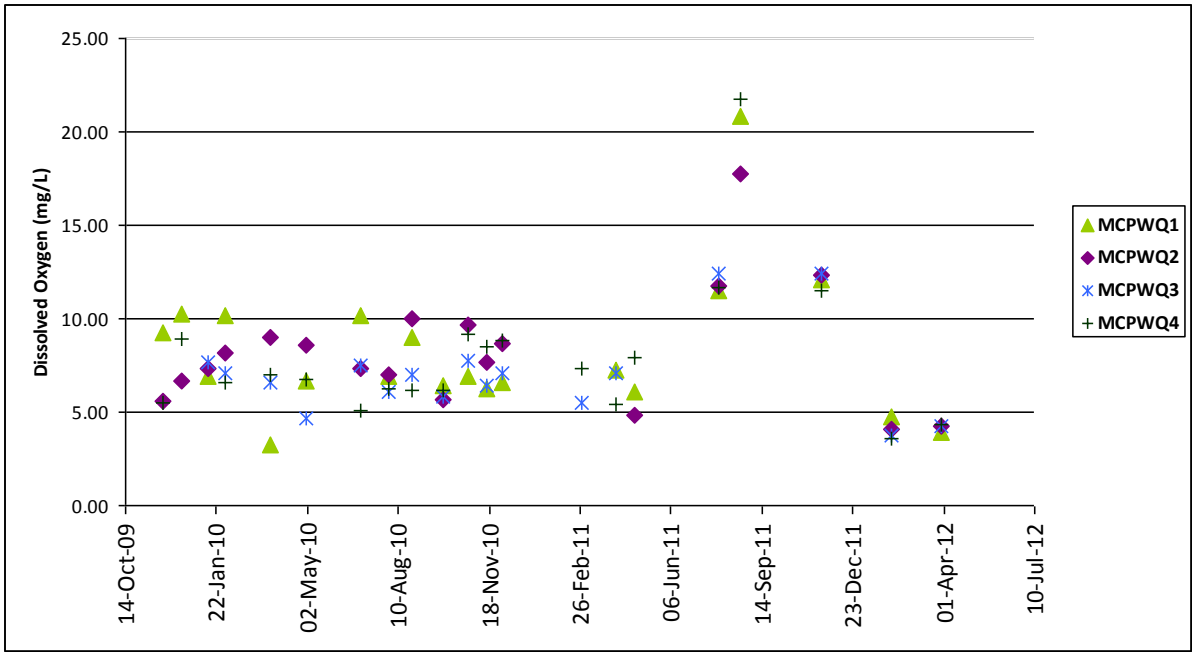

Figure 10: Surface water dissolved oxygen (mg/L), Morgan CP Lagoon, 2009 – 2012.

Vegetation

Vegetation surveys have been conducted to describe and quantify the vegetation at the Morgan Lagoon. The first survey was undertaken in October 2003 and both the Northern and Southern Lagoons were surveyed to identify and record all submerged emergent aquatic species and also riparian species occurring within 20 m of the Lagoon edge.

In January 2004 a second survey was carried out to determine the composition, distribution and abundance of flora on the recently dried Lagoon bed. Five transects running east to west across the bed of each lagoon were established. Between five and eight 1 m² quadrants were placed at 20 to 50 m intervals along each transect to determine the species present, dominant species, vegetation height and the percentage ground cover. Only species below the high water mark were recorded and classified as belonging to the dry lagoon bed zone.
In October 2003 seven photo points were located around the Northern and Southern Lagoons, and 27 photographs were taken showing all the main vegetation associations under these conditions. In February 2004, the vegetation sites were re-photographed when the lagoon had been recently dried.

Thirty-eight plant species were identified over the two surveys during 2003 and 2004 including 12 introduced species and one plant listed as rare in South Australia, the Prickly Bottlebrush (*Callistemon brachyandrus*). Plants were classified as aquatic, emergent, dry Lagoon bed or riparian according to the location and growth pattern of the species. Of the 38 plant species identified, 15 were recorded under two classifications.

The vegetation survey undertaken during 2003 revealed plant species that were typical of the South Australian River Murray wetlands. The high number of introduced species is an indication of past human impact on the site. Table 9 describes the twelve vegetation zones in and around the Morgan Lagoon. The description of the vegetation zones was adapted from the DENR River Murray floristic data set.

During the 2004 survey quadrants located at the edge of the dry lagoon, contained significantly greater number of species than the quadrants surveyed in the middle of the lagoon, possibly due to the quadrants being located within a transition zone at the edge of the lagoon where both emergent, dry Lagoon bed and riparian species can occur.

Quadrants surveyed within the middle of the lagoon showed less diversity. They were dominated by the introduced Swamp Chinese Lantern (*Abutilon theophrasti*), which occurred in 24 of the quadrants (75 per cent of all quadrants), the dominant species in the edge quadrants included Pale Knotweed (*Persicaria lapathifolia*),

Spiny Sedge (*Cyperus gymnocaulos*) and Common Reed (*Phragmites australis*). The frequency distributions of all the dry lagoon plant species are shown in Figure 12.

Vegetation surveys were again undertaken during a wet phase in March 2010. Surveys were conducted at four sites at the lagoon, both the Northern and Southern Lagoons were surveyed to identify and record all submerged and emergent aquatic species and also riparian species. At each site 20 x 2 meter quadrants along 3 transects which were 10m apart to get a combined frequency score out of 60 for each site. Nineteen species of plants were recorded of these 18 species were native and only one introduced species was recorded. Dominant species included Azolla (*Azolla filiculoides*), Duck weed (*Lemna minor*), Common Water Milfoil (*Myriophyllum papillosum*), and Ribbon weed (*Vallisneria americana*). One plant listed as rare in South Australia, the Prickly Bottlebrush was recorded during this survey. The frequency distributions of all the plants species surveyed are in shown Figure 13.

In May 2004, a visual assessment was made of mature River Red Gum health using a six-point scale as described in Tucker (2004). The assessment included mature trees with a diameter greater than 30 cm, and trees within 40 m of the east and west bank of the Northern and Southern Lagoons.

A total of 146 mature River Red Gums were assessed for health, 30% of which received a rating of 5, showing no visual signs of stress. 10 per cent of trees scored a rating of 1 to 2 reflecting a severely stressed state with less than 25 per cent of their original canopy present, predominantly epicormic growth and many dead branches. While the results of this study revealed the poor health of many of the River Red Gums surrounding Morgan Lagoon, there is a concern they may be beyond the reach of any influences brought on by hydrological manipulation, and any improvements to the health of these trees would only come about as a result of overbank flooding.

Figure 11: Vegetation zones of Morgan CP

Table 9: Vegetation Zones of Morgan CP wetland complex and Vegetation Description Key

Vegetation Zones	Species
1	*Eucalyptus camaldulensis / Phragmites australis*
2	*Eucalyptus camaldulensis / Eucalyptus largiflorens / Acacia stenophylla / Muehlenbeckia cunninghamii*
3	*Eucalyptus camaldulensis / Callistemon brachyandrus*
4	*Eucalyptus camaldulensis / Muehlenbeckia cunninghamii / Cyperus gymnocaulosa*
5	*Eucalyptus camaldulensis / Muehlenbeckia cunninghamii /Sporobolus mitchelli*
6	*Eucalyptus camaldulensis / Cyperus gymnocaulos / Cyperus exaltatus a*
7	*Eucalyptus largiflorens / Callistemon brachyandrus*
8	*Muehlenbeckia cunninghamii / Sporobolus mitchelli*
9	*Typha ssp*
10	*Typha ssp / Bolboschoenus caldwellii*
11	*Vallisneria americana / Myriophyllum verrucosum / Azolla filiculoides*
12	*Vallisneria americana /* Open water

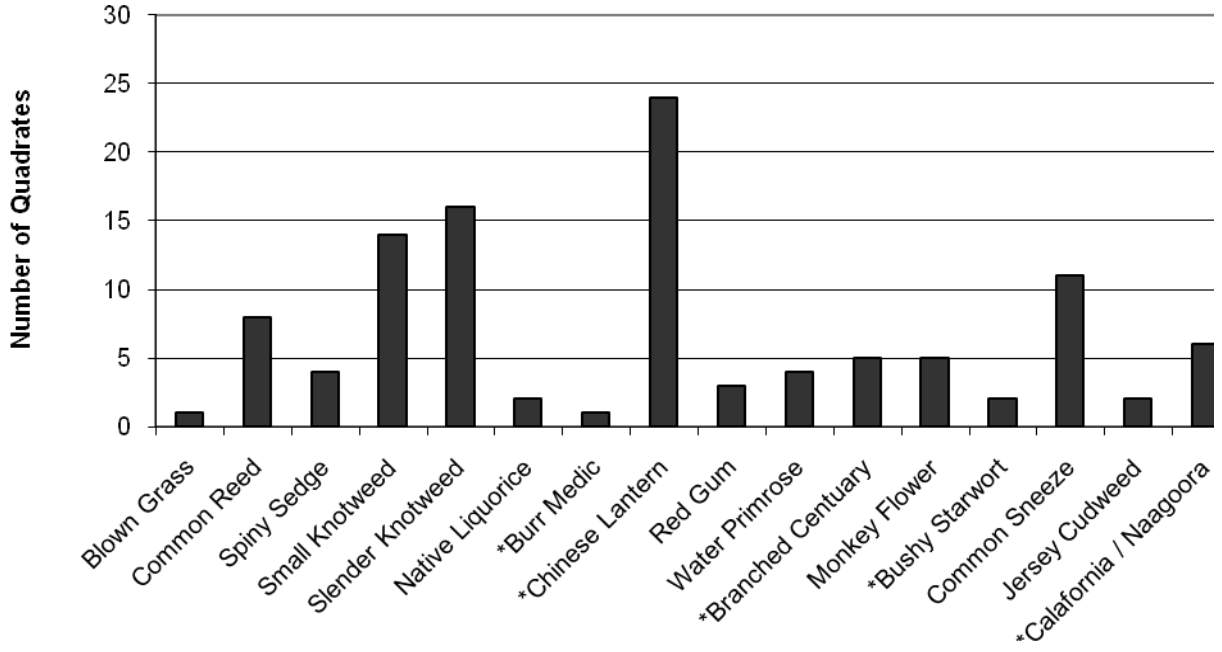

Figure 12: Frequency distribution of dry Lagoon species recorded in a vegetation survey of Morgan CP in January 2004. (*Denotes introduced species).

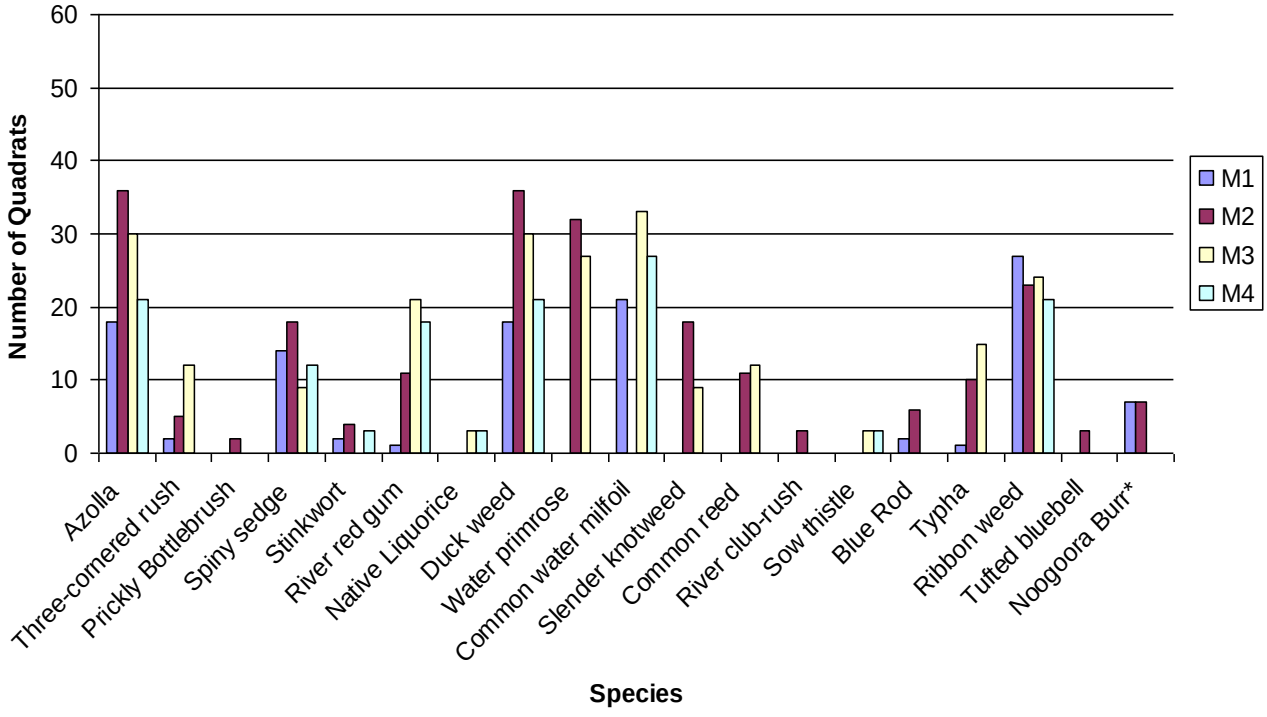

Figure 13: Frequency distribution of aquatic species occurring during a vegetation survey of Morgan CP Lagoon in March 2010.

Birds

Monthly waterbird surveys have been conducted at Morgan CP since 2003. In total, 48 species of waterbird (n=38,257 individuals) have been recorded at Morgan CP during this time (See Appendix D). The most abundant species of waterbird recorded to date is Eurasian Coot (*Fulica atra*) (n=16 920), followed by Grey Teal (*Anas gracilis)* (n=10 814) and Hardhead (*Aythya australis*) (n=1232).

Three species of state significance were detected: the Australasian Shoveler (*Anas rhynchotis*), Musk Duck (*Biziura lobata*), Blue-billed Duck (*Oxyura australis*) are listed as 'Rare' and the Freckled Duck (*Stictonetta naevosa*) listed as 'Vulnerable' in South Australia under the *National Parks and Wildlife Act 1972*.

Bird species observed at the utilised a variety of vegetation and habitat types found at Morgan CP Lagoon. Habitat types include open water, muddy shorelines, fringing vegetation and River Red Gums. These habitat types directly correlate with the functional groups of individual species observed such as ducks and small grebes, large waders, shorebirds, piscivores and herbivores. Many of these species are reliant on habitat and resources created by fluctuations in wetland hydrology. For example, shoreline waders such as Common Greenshank (*Tringa* nebularia) and Latham's Snipe (*Gallinago hardwickii*) have been observed when the wetland is undergoing periods of draw-down, utilizing the exposed muddy fringes for foraging. Future management actions should consider the habitat and breeding requirements of waterbirds given the number of species recorded of conservation significance.

Ducks and small grebes were typically the most common assemblage when abundance was examined based on functional group and were observed in nearly all survey periods (See Appendix E). Shorebirds were the least common functional group encountered, with the Black-winged stilt being the most common species within this assemblage. Shorebirds are highly dependent on the hydrology of a wetland requiring shallow wetland edges for foraging and receding water levels to stimulate food resources (Rogers and Ralph, 2011). At Morgan CP, shorebirds were typically observed as the wetland was drawing down, for example between January and March 2006 and between October and December 2006.

Overall, waterbird abundances were greater between 2003 and 2006 (n=12 747) compared with the period between 2007 and 2012 (n=2955). The wetland was completely dry between January 2007 and March 2009, which would partially explain the low numbers observed in the latter period. In addition, the River Murray underwent a period of extreme drought between 2000 and 2010. The high abundance of waterbirds between 2003 and 2006 may indicate that the site provides important refugia during drought.

Regent Parrot

The Regent Parrot is an iconic species that is listed as 'Vulnerable' under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act 1999). This species regularly nests in the hollows of River Red Gums along the river corridor and Morgan CP provides important habitat. Nest site surveys have been conducted within Morgan CP on four occasions between 2003 and 2010 to record the number of trees used for nesting the number of tree hollows. Although numbers have been relatively stable over this period, there was a decline in nests observed in 2010 (Figure 14). The highest number of nest hollows recorded (n=19) was in 2008.

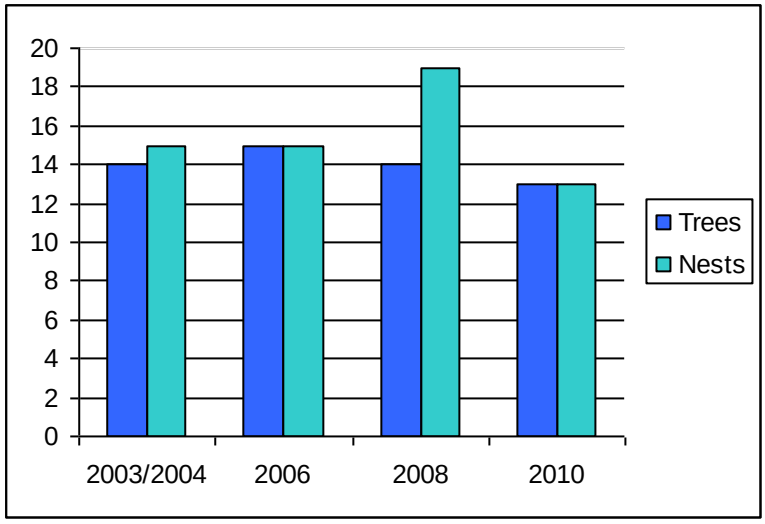

Figure 14: Regent Parrot nest tree and nest hollow counts at Morgan CP.

Fish

Fish surveys have been conducted at Morgan CP on five occasions between 2006 and 2011 (Appendix F). Four sites are surveyed on each sampling occasion; two in the Northern Lagoon and two in the Southern Lagoon. In total, 12 species of fish were recorded (n=13 089) consisting of 8 native species and 4 introduced species. Carp Gudgeon (*Hypseleotris* spp.) was the most abundant species recorded (n=7957) followed by the introduced species Eastern Gambusia (*Gambusia holbrooki*) (n=3365) and Common Carp (*Cyprinus carpio*) (n=1518).

Total individuals captured were highest in 2006 (October 2006, n=4248; January 2006 n=2423). In both instances, Carp gudgeon accounted for a large proportion of the individuals captured. Although fewer individuals were recorded in total during 2010 and 2011, there were a higher number of species captured during these surveys.

One species of conservation significance was recorded at the site in November 2011. Freshwater Catfish (*Tandanus tandanus*) (n=1) is listed as a 'Protected' species under the South Australia Fisheries Management Act 2007.

Frogs

Since 2005, thirteen call surveys have been conducted at between 2 and 4 sites at Morgan CP (Table 10). In total, seven species of frog were recorded during these surveys. The most abundant species recorded was Eastern Sign-bearing Froglet (*Crinia parsignifera*), which was present at 35 of the sites surveyed and predominantly recorded in high numbers (i.e. 'many' and 'lots'). Spotted Grass Frog (*Limnodynastes tasmaniensis*) and Peron's Tree Frog (*Litoria peronii*) were regularly present at the site, but in lower abundances. Common Froglet (*Crinia signifera*) and Painted Frog (*Neobatrachus pictus*) were only recorded at Morgan CP at two and one sites respectively during the entire survey period. Long-thumbed Frog (*Limnodynastes fletcheri*) was not recorded at the site.

Southern Bell Frog (*Litoria raniformis*) was the only frog species recorded of conservation significance (Table 11). The species is listed as 'Vulnerable' under both the EPBC Act 1999 and National Parks and Wildlife South Australia (NPW) Act 1972. Southern Bell Frogs were recorded on most survey occasions, indicating that this is an important site for the species. Highest abundances were recorded in January 2006 when greater than 50 individuals were observed at each of the four sites.

Table 10: Frog monitoring data, Morgan CP Lagoon 2005-2010.

Species	None	One	Few	Many	Lots	Total Presence
Peron's Tree Frog - *Litoria peroni*	30	2	12	8	2	**24**
Southern Bell Frog - *Litoria raniformis*	32	0	15	6	1	**22**
Eastern Sign Bearing Froglet - *Crinia parinsignifera*	19	1	7	15	12	**35**
Common Froglet - *Crinia signifera*	52	0	2	0	0	**2**
Eastern Banjo Frog - *Limnodynastes dumerili*	33	0	16	5	0	**21**
Long Thumbed Frog - *Limnodynastes fletcheri*	54	0	0	0	0	**0**
Spotted Grass Frog - *Limnodynastes tasmaniensis*	23	0	8	21	2	**31**
Painted Frog - *Neobatrachus pictus*	53	0	1	0	0	**1**

Table 11: Southern Bell Frog abundance, Morgan CP Lagoon 2005-2010.

Site	Sep-05	Dec-05	Dec-05	Jan-06	Sep-06	Nov-06	Apr-09	Sep-09	Nov-09	Feb-10	Aug-10	Sep-10	Nov-10	Aug-10
1	None	None	Few	Many	None	None	None	None	None	Many	-	None	None	Few
2	Few	None	Lots	Many	None	None	None	None	None	None	None	None	Few	Few
3	Many	Few	-	Many	None	None	None	Few	None	None	-	None	Few	Few
4	Few	None	-	Many	Few	None	Few	None	Few	Few	-	-	None	None

Wetland management objectives

The management objectives for Morgan Conservation Park have been revised based on:

1. A review of the original management plan objectives and hydrograph(Jensen *et al*, 1999);
2. Monitoring data from the wetland;
3. Observed changes in the site's condition since the development of the original plan (largely due to drought and flood), and;
4. Research and management information that has become available since the development of the original management plan.

The revised objectives for Morgan Conservation Park, which aim to support the site's recovery from the effects of the recent drought and flood, and create a healthy and resilient wetland supporting a range of native biota, are:

1. Re-store the semi-permanent nature of Morgan Lagoon. Using the inlet structure, water levels in Morgan Lagoon have been actively managed to mimic a somewhat natural hydrology regime (wetting and drying). This has had a positive impact on the environmental values of the wetland.

2. Maintain or improve the diversity and area of vegetation including littoral and fringing zones and submerged and emergent aquatic vegetation. Since 2007, 41 species of plants have been recorded at Morgan Conservation park during wet and dry phases

3. Maintain the band of regenerated River Red Gum located around the edge of Morgan Lagoon. The River Red Gums are of particular importance as they occur in both mature and regenerating stands. Bands of mature River Red Gums with a high conservation value have been identified along the channel at the end of the Southern Lagoon. In addition for future management of Morgan Conservation Park is the occurrence of healthy stands of several age classes of regenerating River Red Gum, particularly at the northern end of the Morgan Lagoon and a band of young trees around the Lagoons themselves.

4. Maintain or improve the abundance and diversity of waterbird species foraging and breeding. Since 2007, 36 species of water birds have been recorded at Morgan Conservation Park including four species of Conservation significance: Australasian Shoveler (*Anas rhynchotis*), Musk Duck (*Biziura lobata*) and Blue-billed Duck (*Oxyura australis*).

5. Maintain or improve the diversity and abundance of frog species. Since 2007, six species of frogs have been recorded within Morgan Conservation Park including the listed Southern Bell Frog (*Litoria raniformis*), which has been recorded in moderate to high numbers.

6. Maintain or improve the diversity and abundance of native fish and reduce the abundance of introduced fish species. Since 2007, 9 native species of fish have been captured at Morgan Conservation Park including one species of conservation significance, the Freshwater Catfish (*Tandanus tandanus*).

7. Promote the establishment of Slender Knotweed *Persicaria decipiens* on the lagoon dry bed at least every second dry event.

Objective 1: Re-store the semi-permanent nature of Morgan CP Lagoon.

Rationale

Permanently flooded wetlands are biologically less productive than temporary wetlands, in the presence of water, important plant nutrients such as nitrates and phosphates stay chemically bound to the clay particles of the wetland bed. If the wetland dries, the chemical bonds are broken and the nutrients are dissolved into the water, when the wetland is next flooded, providing nutrients for plant growth and triggering the breeding of wetland fauna (Thompson, 1986). When a wetland is dried, the resultant growth of terrestrial vegetation on the lagoon bed is also important, as on re-flooding it can provide habitat for macroinvertebrates and fish. Plant seeds also become an important food source for waterbirds. The alternation of wet and dry cycles is therefore essential for the long-term health of wetlands and their flora and fauna that have evolved to respond to this cycle (Van der Valk 1981).

The construction of weirs in the River Murray and agricultural practices such as irrigation and vegetation clearing have resulted in rising levels of saline groundwater (Thompson, 1986). Rising saline water tables have the potential to salinise wetlands particularly where hydrological regimes have been changed, and for this reason well-designed management and monitoring programs are necessary in order to avoid this.

Targets

The specific targets associated with meeting this objective are to:

- Implement a hydrological regime which incorporates fluctuations that promote food production, support the establishment and increased condition of habitat and promotes successful fauna breeding activity.
- Drying cycles of the lagoon should only occur during autumn and winter to restrict the spread of Water Couch (Huang et al., 1987).
- Vary the wetland hydrology in order to increase the habitat and diversity of wetland vegetation.
- Maintain or increase native fish, frog and waterbird population across the wetland.

Management Actions

The actions recommended in this management plan are expected to contribute to the achievement of the following objectives:

- Restore a variable hydrological regime

Monitoring

The monitoring associated with this objective to inform management and measure success is:

- Tree health condition monitoring
- Colony surveys of Regent Parrot nesting sites

Objective 2: Maintain or improve the diversity and area of vegetation including littoral and fringing zones and submerged and emergent aquatic vegetation.

Rationale

Submerged, emergent and littoral vegetation provides critical resources and aquatic and riparian habitat for a range of aquatic biota, including waterbirds, fish, frogs, crustaceans and macroinvertebrates. Long-lived flood-dependent vegetation such as River Red Gums and Lignum (*Muehlenbeckia florulenta*), also provide important habitat and ecological functions. For example River Red Gums contribute dissolved organic carbon to the River and moderate water temperatures through shading (Roberts & Marston, 2011).

Targets

The specific targets associated with meeting this objective are to:

- Within the wetland encourage the establishment and growth of submerged and emergent vegetation species.
- Support the recruitment of submerged vegetation following the complete dry phase.
- Recruitment of littoral zone vegetation species (via germination and vegetative expansion) following draw down events;

Management Actions

The actions recommended in this management plan are expected to contribute to the achievement of the following objectives:

- Implement a hydrological regime which includes variations in water levels (to allow wetting and drying of the root zone of vegetation) in order to increase the area and diversity of wetland vegetation,

Monitoring

The monitoring associated with this objective to inform management and measure success is:

- Photopoint monitoring,
- Incidental monitoring of vegetation presence, condition and abundance across the site,
- Recording of recruitment events following overbank flood events, drawdown and refill events.

Objective 3: Maintain or improve River Red Gum health within the hydrological influence of the wetland

Rationale

River Red Gums (*Eucalyptus camaldulensis* var. *camaldulensis*) provide important ecological function within riparian and wetland habitats. These functions include providing critical habitat for a range of biota, influencing water temperature via shading and contributing organic carbon to the River, while also moderating water temperature via providing shade (Roberts and Marston, 2000).

River Red Gums provide important resources for the Regent Parrot (*Polytelis anthopeplus monarchoides*), which is listed as 'Vulnerable' under the South Australian *National Parks and Wildlife Act 1972*. This species breeds annually here, relying on the hollows of River Red Gums for nesting. Sighting records also indicate that the Regent Parrot is a regular inhabitant of the site throughout the non-breeding season.

In addition, a large number of seedlings have germinated following the recent flood event in 2011 and 2012. It is important that hydrological regimes be implemented that support these recruitment events.

Future management of Morgan CP Lagoon should consider the importance of healthy stands of several age classes of regenerating River Red Gum, including hollow bearing trees with the capacity to provide suitable nest sites for Regent Parrots.

Previous studies have recorded the accelerated growth of River Red Gum in relation to the abundant sources of surface waters (Kidson et al. 2000a; Robertson et al. 2001) and regular periods of spring flooding are beneficial to the productivity of River Red Gums (Robertson et al. 2001).

Targets

The specific targets associated with meeting this objective are to:

- Maintain or improve the condition of River Red Gums, Black Box and Lignum and other flood-dependent vegetation that has established around the wetland basin since the 2010/11 flood event.
- Maintain or increase the number of breeding Regent Parrots within the site

Management Actions

The actions recommended in this management plan are expected to contribute to the achievement of the following objectives:

- Implement a hydrological regime which is includes variations in water levels (to allow wetting and drying of the root zone of vegetation) and reduces surface water conductivity,
- Undertake weed control activities, and;

Monitoring

The monitoring associated with this objective to inform management and measure success is:

- Tree health condition monitoring
- Whole of river and colony surveys of Regent Parrot nesting sites

Objective 4: Maintain or improve the diversity and abundance of waterbird species foraging and breeding

Rationale

Waterbirds are an important component of floodplain and wetland ecosystems, with different species utilising a variety of food sources (i.e. invertebrates, plants, frogs and fish) (Cale, 2008). Additionally, waterbirds are generally top-order predators and are considered to be good indirect indicators of other species (e.g. vegetation, invertebrates, fish and frogs). Consequently, waterbirds are considered to be useful indicators of general ecosystem health (Kingsford and Lee, 2007).

The aim of the proposed hydrological regime is to maintain or improve the diversity and abundance of waterbird species from a range of functional groups by providing favourable conditions as both a foraging and breeding site.

Targets

The specific targets associated with this objective are to:

- Record a diverse range of water bird species during surveys – across a range of functional groups and abundances utilizing a range of habitats,
- Record evidence of species breeding,
- Continue to record species of conservation significance and abundances of existing species.

Management Actions

The actions recommended in this management plan are expected to contribute to the achievement of the following objectives:

- Provide a range of hydrological conditions that maximise abundance of waterbirds from a range of functional groups

Monitoring

The monitoring associated with this objective to inform management and measure success is:

- Waterbird monitoring

Objective 5: Maintain or improve the diversity and abundance of frog species

Rationale

Frogs form an important component of wetland ecosystems. Frogs (and/or their eggs and tadpoles) are included in the diet of a wide range of fauna including fish (Lintermans, 2007), waterbirds (grebes, cormorants, egrets, herons, terns swamphens, lapwings, spoonbills and ibis) (Rogers, 2011), turtles (Georges, et al., 1986), snakes (including the threatened Carpet Python - *Morelia spilota*) (Department for Environment and Heritage, 2008) and other frogs (such as Southern Bell Frogs) (Mallee CMA, 2009).

The aim of the proposed hydrological regime is to improve the abundance of species types and individuals across the wetland and to provide suitable areas and resources for breeding activities.

Targets

The specific targets associated with meeting this objective are to:

- Record at least three species of frog during frog surveys.
- Increase species diversity and abundance.
- Detect tadpoles during fish surveys

Management Actions

The actions recommended in this management plan are expected to contribute to the achievement of the following objectives:

- Implement a hydrological regime that incorporates fluctuating water levels to stimulate food resource production, improve habitat quality and promotes successful breeding events.
- Where possible maintain surface water conductivity below ~3000 µS/cm over the peak spring/summer breeding season.
- Maintain water level in the wetland at near capacity into mid-summer to ensure the majority of tadpoles are able to complete metamorphosis before conductivity levels rise beyond tolerance levels.
- Manage invasive fish species to reduce predation of frogs and eggs.

Monitoring

The monitoring associated with this objective to inform management and measure success is:

- Frog monitoring;
- Fish monitoring (may yield incidental tadpole records), and;
- Littoral zone and submerged vegetation monitoring

Objective 6: Maintain or improve the diversity and abundance of native fish and reduce the abundance of introduced fish species

Rationale

Native fish are an important food resource for many wetland birds and their survival is threatened by loss of habitat, competition with introduced fish species, prolonged drought events, water quality changes and River regulation, particularly the changes to natural flow regimes and flood events (Tucker, 2003; Hammer, et al., 2009).

Habitat loss in Morgan CP Lagoon, both submerged and riparian edge habitat, is likely to affect the population and community composition of native fish found within the wetland. It is anticipated that the proposed hydrological regime will provide the optimal conditions for the germination, growth and condition of aquatic macrophytes and riparian edge vegetation.

In addition, introduced fish species can impact negatively on biodiversity within wetland ecosystems. For example, Common Carp impact the environmental and cultural values of wetlands through the creation of high levels of turbidity, damage to vegetation (Allen, et al., 2002), competition with native fish for resources (Lintermans, 2007) and potentially reducing frog recruitment through predation (Wassens, 2011).

Targets

The specific targets associated with meeting this objective are:

- Record a range of small and large bodied native fish during surveys.
- Observe and record breeding activity in native fish (e.g. the presence of fingerlings, females running ripe).
- Record low species abundances and diversities of invasive species.
- Encourage the establishment of aquatic macrophytes within the wetland basin.

Management Actions

The management actions recommended in this management plan which will contribute to the achievement of this objective are:

- Implement a hydrological regime which incorporates variable hydrology anticipated to promote food production, support the establishment and improves the condition of habitat and supports successful breeding response.
- Control Common Carp and other introduced species

Monitoring

The monitoring associated with this objective to inform management and measure success is:

- Fish surveys

Objective 7: Promote the establishment of Slender Knotweed (*Persicaria decipiens*) on the lagoon dry bed at least every second dry event

Rationale

Slender knotweed (*Persicaria decipiens*) is an annual forb that occurs in shallow water, swamps, depressions and other damp places. Slender knotweed has been observed recolonising the wetland bed post drawdown phase. After the wetland has been refilled the inundated slender knotweed becomes important habitat for a variety of native fish and frogs, in particular the Southern bell frog.

Targets

The specific targets associated with meeting this objective are:

- Presence of Slender-knotweed prior to refilling the wetland. Further research may be required to determine the most appropriate coverage required to achieve optimal habitat.

Management Actions

The management actions recommended in this management plan which will contribute to the achievement of this objective are:

- A sufficient dry phase should be achieved to allow Slender knotweed to establish on wetland bed

Monitoring

The monitoring associated with this objective to inform management and measure success is:

- Photopoints
- Incidental observations

Proposed wetland management 2012-17

Hydrological management

To achieve the management actions for Morgan CP Lagoon it is recommended that the site undergoes two complete dry phases and one partial dry phase. When implementing different hydrological phases of the wetland it is important to consider the following:

Dry phase

- Wetland is completely dry for up to 3 months and no more than 6 months.
- Drying commences in January 2013, January 2015 and a partial dry in March 2017.

A short dry phase allows wetland bed plants to become established and set seed. These seeds become an important source of food for waterbirds, and terrestrial plants once inundated. Established wetland bed plants also provide habitat and food for macro invertebrates and fish.

This dry phase should also allow time for clay sediments to consolidate. If they are not strongly consolidated there is a risk of high turbidity levels on re-filling causing low light conditions that will limit the germination and subsequent survival of submerged plant species (Tucker et al., 2002).

Wet phase

- Refilling occurs in January 2014, September 2015 and after the partial drawdown in September 2017.
- The wetland should be opened and remain connected to the main River channel during these alternating wet cycles.

Long lived vegetation in the riparian zone have specific water stress tolerances and although mature River Red Gums can tolerate extended flooding in their root zone of 18 to 24 months, Red Gum seedlings and Lignum will not tolerate floods of extended duration. However the young river Red Gums and Lignum around the edge of Morgan Lagoon have continued to survive and flourish with three 18 month inundations since 2000. However, the risks brought on by a short-dry phase and a 12 - 18 month wet-phase in this location are low and the monitoring program described in later sections will identify any potential problems before remedial action is necessary.

A wetland water operational plan has been developed for Morgan CP Lagoon in order to achieve the management objectives previously presented. The wetland operational plan guides the management of the hydrological regime (wetting and drying) in the wetland based on the management objectives. This hydrological management will be achieved through the operation flow channel inlet structure at the wetland. The operational plan has an initial five-year cycle, from January 2013 until December 2017, at which point (if not earlier) it should be reviewed and updated. The aim of the wetland operational plan is to manage (and maintain) a wetting and drying cycle in the wetland from January 2013 until December 2017.

Flow control

Morgan CP Lagoon water level can be manipulated by the existing flow control structure. The remaining wetlands within Morgan CP are temporary wetlands that fill at a flows ranging from 58 000 ML/day – 105 000 ML/day (Jensen *et al*., 1999).

Water Level Fluctuation

Water level fluctuation is a natural occurrence which supports a series of beneficial trophic processes such as nutrient cycling and completion of zooplankton life cycles (Scholz and Gawne 2004, Scholz et al. 2005).

The key element of the Hydrological management of Morgan CP Lagoon is to restore the semi-permanent nature of the wetlands

Refill

It is proposed that following a complete dry phase, refilling of the wetland is as slow as possible (where monitoring supports this decision) at a rate of no more than 3cm/day.

Drawdown Phase

If Morgan CP is drawing down too rapidly, i.e. it is likely to dry completely before it is recommended to, then the flow control structure may be opened to allow the wetland to fill a little, before being closed and the water level allowed to drawdown again, however this may result in the concentration of salts within the wetland basin and therefore careful consideration must be given to determining the appropriate timing for closure.

Unregulated Flow/Flood Events

It is recommended that careful consideration is given to the hydrological management of the wetland to allow water to enter and inundate the surrounding floodplain during unregulated flow and flood events. During these phases the removal of aluminium gates and management of fish screens will be required to be reviewed.

Modification of the Wetland Operation Plan

The wetland water operational plans should be considered as a guide to the hydrological management of the site and should therefore be modified, as appropriate, if monitoring results provide and support sufficient evidence to initiate a change in management strategies. The changes in the wetland operational plan may occur as a result of the findings from monitoring, which will be undertaken for the duration of the management period, as a result of natural processes such as high flow events, flows negotiated for environmental benefits (such as spring pulse), or as directed by water management authorities. Natural processes in particular drought and flood events, are highly likely to require the wetland operational plan to be modified. These will affect the management of the site.

When a wetland operational plan is implemented, it is important to consider different stages in the wetting and drying cycle, and the physical and biological impacts upon the wetland ecosystem which may arise as a result of these actions. These are discussed at length in *Your Wetland: Hydrology Guidelines* (Tucker, et al., 2002).

Flood Events

Flood events are river flow conditions that may change 'baseline' hydrology. Although the frequency and extent of floods along the River Murray in South Australia has been significantly reduced since river regulation, flood events still occur. Floods are important as they provide cues for native fish spawning and water-dependent bird breeding, provide water to floodplain vegetation and transport nutrients between floodplains and rivers which are utilised by a range of River organisms (Tucker, 2003; Ralph & Rogers, 2011).

Water flows higher than the height of the flow control structures are generally unable to be managed (unless structures are modified). This occurs at Morgan CP Lagoon at approximately 58,000 ML/day. When flow has receded however, there are many opportunities for managing water in the wetland.

Alternatively it may be deemed appropriate that the structure remain open to allow water within the wetland to recede and draw salt out of wetland basin as water levels recede. On-going monitoring will help to determine the most appropriate management action over the duration of the management period.

Large natural floods should not be held out of wetlands as the resulting hydraulic pressure may cause regional saline ground water to rise to the surface in and around the Lagoon. (Tucker *et al*, 2002). At high river levels therefore, the flow control structure should be opened. On the other hand, when the river level recedes during naturally occurring floods, the floodwater should be held in the wetlands to provide for the riparian vegetation outside the immediate influence of the Morgan Lagoon. However, due to the decline in the frequency of naturally occurring floods owing to river regulation and extended periods of drought, this pattern of inundation occurs much less regularly.

As soon as water levels inundate the Cosy Corner Inlet structure and floodwaters start flowing through the Morgan CP Lagoon the large fish exclusion screens will be decommissioned.

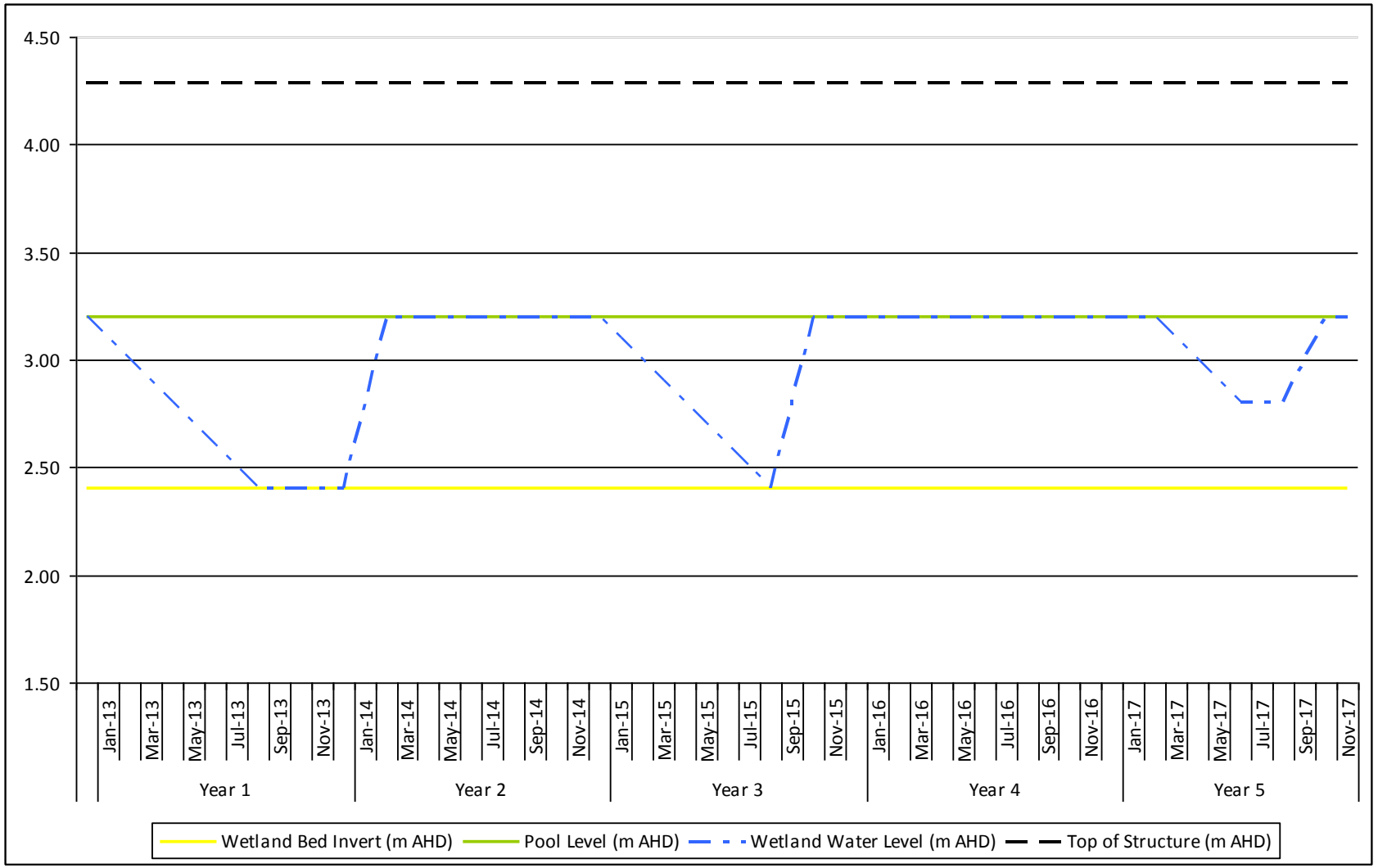

Figure 15: Proposed hydrological regime for Morgan CP Lagoon, 2013-17.

Details of proposed management

Table 12: Proposed Wetland Hydrological Management Regime and Information to Guide the Management of Morgan CP Lagoon 2012 – 2017.

Year	Timing[1] and Duration	Hydrological Phase	Flow control	Associated Management Actions		Description and expected response/s
				Fish Screens	Other	
Year 1 (Jan 2013 - Dec 2013	January 2013 - December 2013 (12 months)	Complete drawdown and dry phase (via evaporation)	Close inlet control structure (Drawdown should occur over about 9 months, complete dry of the wetland bed should be up to 3 months but not exceed 6 months)	Review the management of fish screens throughout the management period [2].		• Germination of dry wetland bed species • Carp control method • Consolidate wetland bed sediments • Draw water from the root zone of River Red Gum and other flood dependent vegetation • Provision of refuge for waterbirds, breeding habitat for macro invertebrates, frogs, fish, and crustaceans such as yabbies and shrimp • Recharge of groundwater (freshwater lens)
Year 2 (Jan 2014 - Dec 2014	January 2014 - December 2014 (12 months	Refill and maintain at pool level	Open inlet control structure			• Provide habitat for wetland biota • Maintain low surface water EC • Create/maintain freshwater lens under wetland bed • Support regeneration of River Red Gum trees and other flood dependent vegetation • Promote recruitment of native wetland biota • Release nutrients stored in wetland bed • Provide refuge and breeding habitat for waterbirds, frogs and fish • Water for fringing riparian vegetation including River Red Gums, Lignums, River Cooba, Prickly Bottlebrush, reeds and rushes.
Year 3 (Jan 2015 - Dec 2015	January 2015 - September 2015 (9 months)	Complete drawdown and dry phase (via evaporation)	Close inlet control structure (Drawdown should occur over about 9 months, complete dry of the wetland bed should be up to 3 months but not exceed 6 months)			• Germination of dry wetland bed species • Carp control method • Consolidate wetland bed sediments • Draw water from the root zone of River Red Gum and other flood dependent vegetation
	October 2015 - February 2017 (17 months)	Refill and maintain at pool level	Open inlet control structure			• Provide habitat for wetland biota • Maintain low surface water EC • Create/maintain freshwater lens under wetland bed

Year 4 (Jan 2016 - Dec 2016						• Support regeneration of River Red Gum trees and other flood dependent vegetation • Promote recruitment of native wetland biota • Release nutrients stored in wetland bed • Provide refuge and breeding habitat for waterbirds, frogs and fish
Year 5 (Jan 2017 - Dec 2017	March 2017 - September 2017 (7 months)	Partial drawdown phase (via evaporation)	Close inlet control structure (Drawdown should occur over about 5 months, partial dry should be up to 3 months in duration)			• Draw water from the root zone of River Red Gums and other flood dependent vegetation. • Increase the abundance of emergent vegetation and encourage the germination of these down the wetland elevation gradient. • Carp control method. • Consolidate wetland bed sediments.
	October 2017 - December 2017 (3 months)	Refill and maintain at pool level	Open inlet control structure			• Provide habitat for wetland biota • Maintain low surface water EC • Create/maintain freshwater lens under wetland bed • Support regeneration of River Red Gum trees and other flood dependent vegetation • Promote recruitment of native wetland biota • Release nutrients stored in wetland bed • Provide refuge and breeding habitat for waterbirds, frogs and fish

[1] Timings and durations are estimates only. Actual timings and durations will be determined by local conditions (water levels, climate etc).

[2] Common Carp move seasonally between wetlands and the river channel, overwintering in the River and spending the summer breeding in wetlands. Opening screens in autumn may allow large-bodied adult Common Carp to leave the wetland and re-closing the screens in early spring may prevent them from entering the wetland to spawn. This approach may reduce the impact of Common Carp between compete drying events.

Adaptive management

An adaptive management approach needs to be used to manage the wetland. Although the best available information has been used to develop the recommended hydrograph, river conditions and site specific monitoring of physical and ecological parameters throughout the duration of the management period should guide and inform the management of the site.

Ecological Triggers

Examples of ecological triggers and responses for the management of Morgan CP are presented in Table 13 below.

Table 13: Management actions should be reviewed if the following ecological triggers are met.

Trigger/s	Potential response/s
Decline in River Red Gum and other flood-dependent terrestrial vegetation condition	Review potential causes of decline (such as changes in groundwater levels, climatic conditions, hydrological management etc). Consider whether planned management should be altered (including assessment on impacts on changing management on other objectives).
Decline in surface water quality	Examine the extent of change in surface water quality parameters and determine the likely effects on biota. Review management actions and consider whether these actions should be altered to resolve the situation.
Decline in the abundances of species of conservation significance recorded at the site	Consider whether management actions are impacting on these species and alter management as required to remove these threats.
Increasing salinity across the site.	Review the potential cause of increasing salinity across the site. Consider whether a change in the proposed management will result in a negative impact upon other objectives.
Shifting groundwater gradients (increasing towards the wetland) and saline groundwater intrusion.	Determine the threat of shifting groundwater gradients and saline groundwater intrusion to achieving the objectives for the site. Consider whether a change in the proposed management will result impact upon other objectives.
Loss of aquatic vegetation within the wetland body and deterioration in the condition of riparian edge vegetation.	Review potential causes of decline (such as changes in groundwater levels, climatic conditions, hydrological management). Consider whether planned management should be altered (including assessment on impacts of changing management on other objectives).
Increased abundances of adult Common Carp	Examine potential causes of abundance increase and assess the likely impact on management objectives. Review fish screen management and potential need for additional threat mitigation, such as complete dry phase.

Monitoring

Monitoring is an extremely important component and process of wetland management planning which uses the collection of physical and biological data in order to determine the success or failure of a specific management action or strategy. It may also be used to adjust, change or refine management actions, in response to changes which occur within the wetland as a result. Wetland management requires some degree of flexibility and the adaptive management model provides this flexibility. Identifying the positive and negative impacts upon the wetland as a result of specific management actions is important for determining the ecological benefit that will be achieved or derived at the site as a result of the action.

Monitoring at Morgan CP will be ongoing and the Department for Environment Water and Natural Resources will undertake this. Refer to Table 14 for the updated monitoring timetable that will be implemented at Morgan CP.

To ensure that the data collected is comparable to that collected during the baseline survey, it is recommended that further monitoring continues to occur based on the methodology used during these surveys. The monitoring program is outlined in Table 14, which includes monitoring of flora, fauna, surface water and groundwater. The opportunity also exists for monitoring outside the scope of the monitoring program, such as the observations of threatened bird species. Techniques for monitoring physical and biological parameters at Morgan CP should be based on the methods outlines in *Your Wetland: Monitoring Manual* (Tucker, 2004).

Table 14: Monitoring schedule for Morgan CP

Monitoring Activity		Technique	Time Required	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Priority	Respo Coord
FLORA	Vegetation	Tree Health	1 day			x			x			x			x	HIGH	SA MD Board
FAUNA	Birds	Fixed Area Search	½ day			x								x		HIGH	SA MD Board
	Frogs	Recording Frog Calls	2 hours		x						x			x		HIGH	SA MD Board
	Fish	Fyke and Box Traps	2 days*			x						x				LOW	SA MD Board
	Macroinverte-brates/Turtles/ Tadpoles	Record (where incidental sightings)	½ day*			x						x				LOW	SA MD Board
WATER QUALITY	Groundwater	Groundwater depth and salinity from piezometers^	1 day			x			x			x			x	HIGH	SA MD Board, commu group.
	Surface Water	Water Quality (EC, pH, NTU, DO, °C) ^	½ day			x			x			x			x	HIGH	SA MD Board, commu group.
		Water level	1 hour	x	x	x	x	x	x	x	x	x	x	x	x	HIGH	SA MD Board
MANAGEMENT RELATED	Data Management	Update and file all data (2 copies kept in separate locations	1-2 hours/ month	On-going												HIGH	SA MD Board
		Analyse biological and physical data and relate to management actions	1 day		x		x		x		x		x		x	HIGH	SA MD Board
		Update monitoring log book	1 hour	On-going												HIGH	SA MD Board
		Review Wetland Operational Plan	1-2 days*	As Required –minimum every 5 years.												HIGH	SA MD Board
		Report to DfW of any changes to the management plan	2 hours	As required												HIGH	SA MD Board

Reporting, evaluation and review

The principals of adaptive management will guide management of Morgan CP. Management actions will be guided ultimately by the results of the Monitoring Program that will be used to measure the success of management actions in meeting the objectives of the Morgan CP Wetland Management Plan. This process may operate in the short-term when maintaining water levels while water birds are breeding, for example, or in the long-term when measuring the response of native vegetation to management actions. This process assists in further identifying any changes that need to be made to management actions or management plan objectives.

Any modification or changes to the management objectives, Wetland Water Operational Plan or the Monitoring Program will be documented by the DEWNR Wetlands Officer and reported to the relevant authority. In addition, it is a requirement of holding a water licence and allocation that an annual report be prepared and submitted to the relevant authority.

This plan will be reviewed in 2015.

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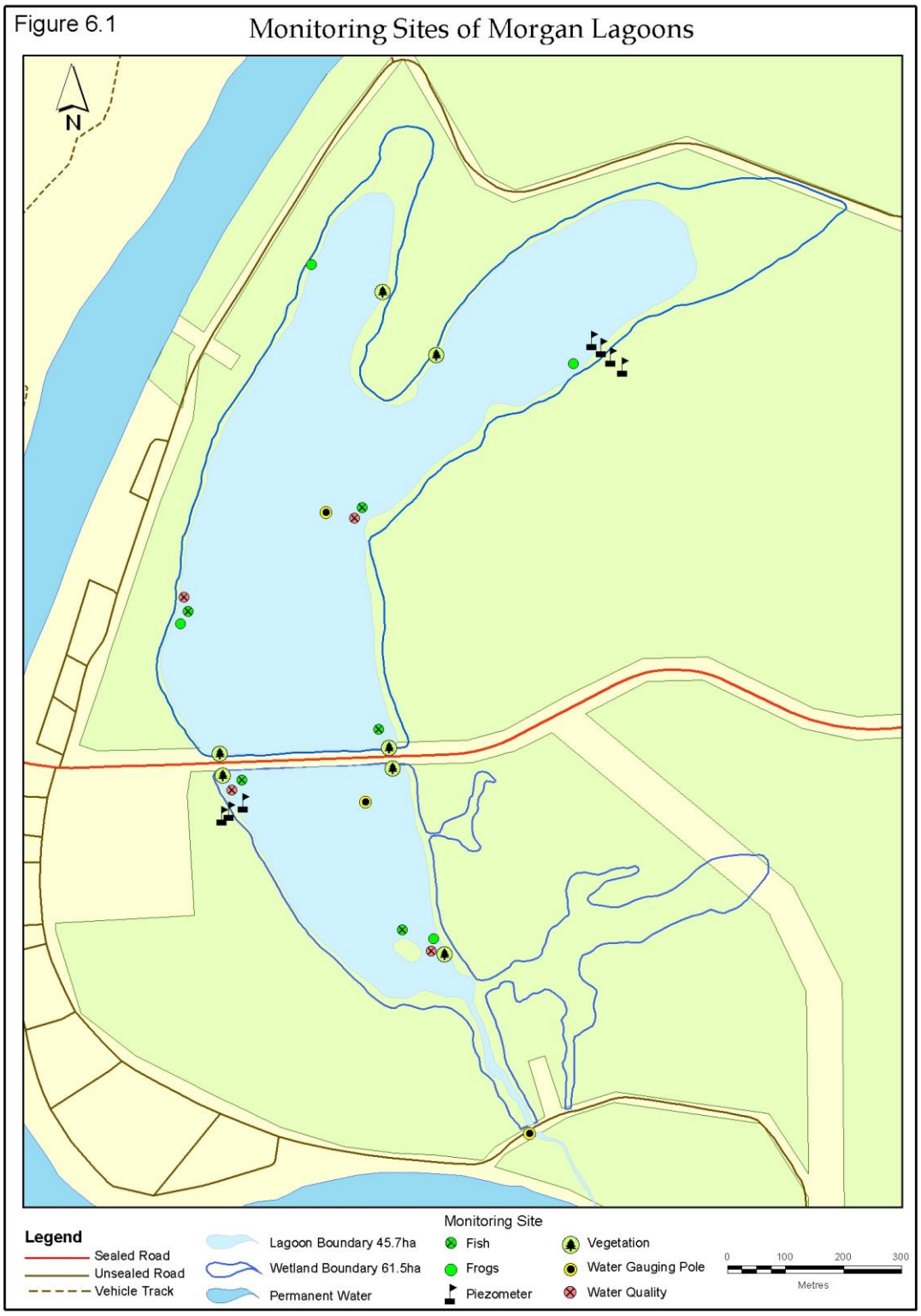
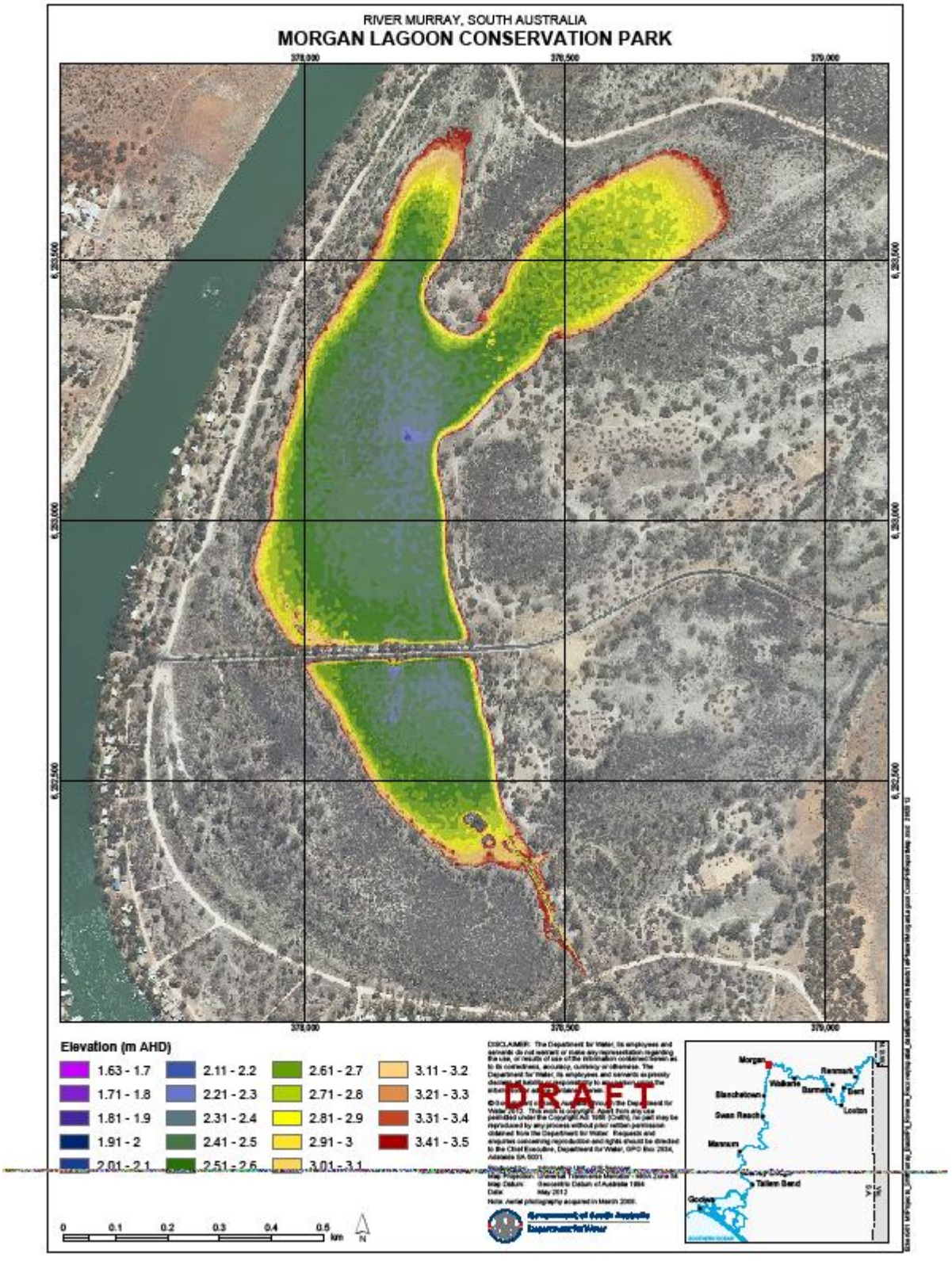
Appendix

Appendix A: Monitoring sites at Morgan CP



Appendix B: Morgan CP Lagoon bathymetry map



Appendix C: Plant species observed during two surveys of Morgan Lagoon, 13 October 2003 and 15 January 2004.

Common name	Species	Survey 1	Survey 2
Aquatic species			
Azollaceae			
Red Azolla	*Azolla filiculoides*	✓	
Onagraceae			
Water Primrose	*Ludwigia peploides*	✓	✓
Haloragaceae			
Red Water-Milfoil	*Myriophyllum verrucosum*	✓	✓
Hydrocharitaceae			
Ribbon Weed	*Vallisneria americana*		✓
Emergent species			
Typhaceae			
Cumbungi	*Typha spp.*[1]	✓	✓
Poaceae			
Water Couch	*Paspalum distichum*		✓
Common Reed	*Phragmites australis*	✓	✓
Three-Corner Bulrush	*Bolboschoenus caldwellii*	✓	
Cyperaceae			
Giant Sedge	*Cyperus exaltatus*	✓	
Spiny Sedge	*Cyperus gymnocaulos*	✓	✓
Juncaceae			
Common Rush	*Juncus usitatus*	✓	
Polygonaceae			
Pale Knotweed	*Persicaria lapathifolia*	✓	✓
Slender Knotweed	*Persicaria decipiens*		✓
Mud Dock	*Rumex bidens*	✓	
Scrophulariaceae			
Australian Mudwort	*Limosella australis*	✓	

Appendix D: Waterbird monitoring data, Morgan CP

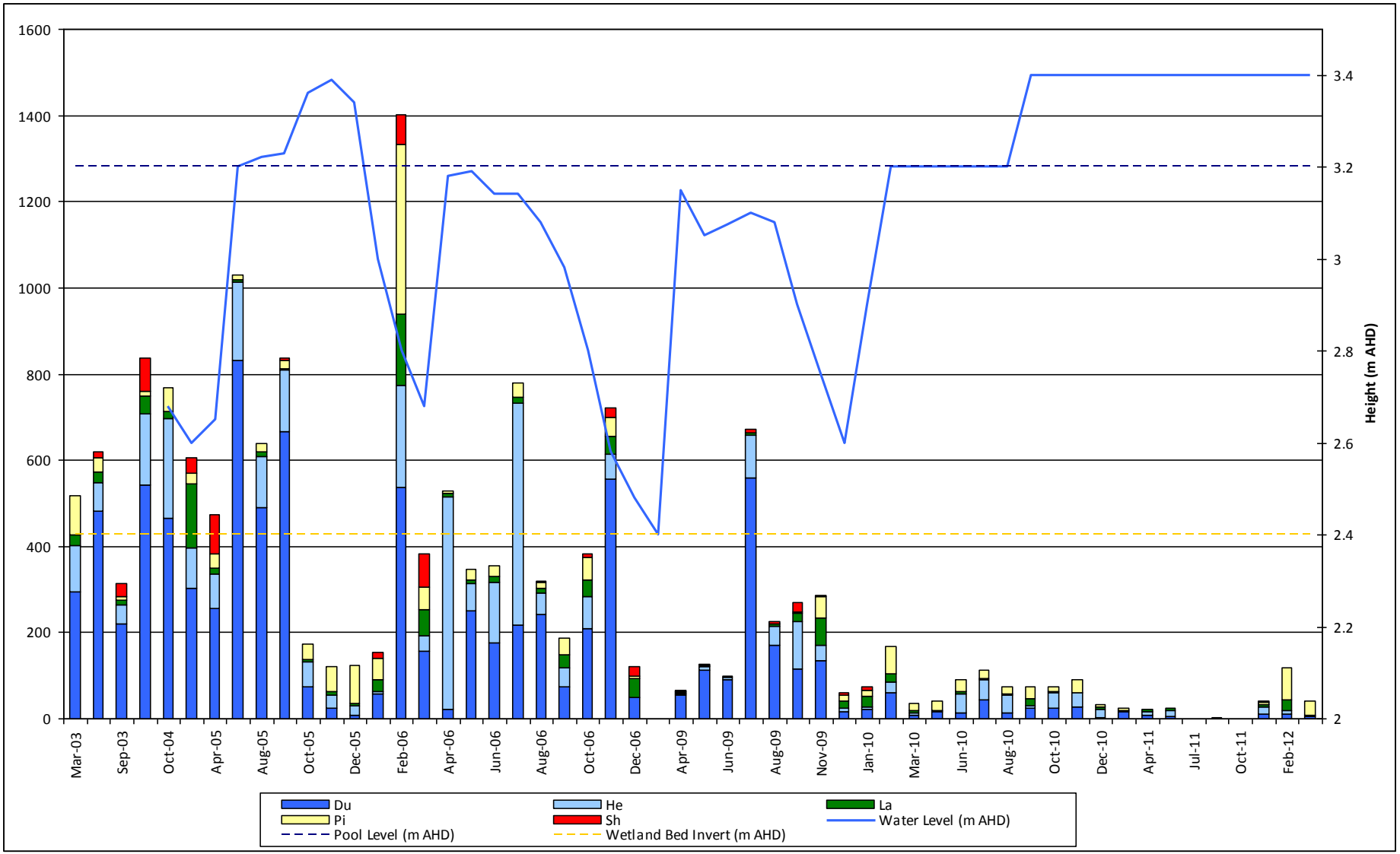
Date	20-Dec-05	24-Jan-06	23-Feb-06	20-Mar-06	27-Apr-06	24-May-06	29-Jun-06	25-Jul-06	30-Aug-06	27-Sep-06	26-Oct-06	30-Nov-06	20-Dec-06	27-Apr-09	26-May-09	24-Jun-09	23-Jul-09	28-Aug-09
Australian Grebe *Tachybaptus nuovaehollandiae*	2		2			2	1	15	6	4	12				4		4	8
Hoary -Headed Grebe *Poliocephalus poliocephalus*		2		1	1	29	64	14	24	6								
Australian Pelican *Pelecanus conspicillatus*	56	8	249	47	2	11	6	1		11	48	38	1					1
Great Cormorant *Phalacrocorax carbo*		23	3				2	16			3							
Little Black Cormorant *Phalacrocorax sulcirostris*	17	9		1			1	2	3	26		2				1	1	
Pied Cormorant *Phalacrocorax varius*										2								
Little Pied Cormorant *Phalacrocorax melanoleucos*	14	8	142	7	4	14	16	16	11		2			2	2			
Australian Darter *Anhinga novaehollandiae*	2																	
White-necked Heron *Ardea pacifica*			1	1								1						
Great (Large) Egret *Egretta alba*		11	27	13		4	1	1		1	1						1	1
White-faced Heron *Egretta novaehollandiae*	2	2	33	25	5	2	3	2		3	7	4	13	1	1	1		
Australian Ibis *Threskiornis molucca*	3	1	81	3	1			1	7	12	11	13	18	2				
Straw-necked Ibis *Carphibis spinicollis*																		
Glossy Ibis *Plegadis falcinellus*																		
Royal Spoonbill *Platalea regia*		3	4	2					1			1						
Yellow-billed Spoonbill *Platalea flavipes*		6	7	1	1	1	11	9	2	11	16	1						
Black Swan *Cygnus atratus*	1		1	9	78	5	45	2	2	2	9	3		2	4	6	74	29
Freckled Duck *Stictonetta naevosa*		2					9											
Australian Shelduck *Tadorna tadornoides*				2				8	1		2			6	5		4	16
Pink-eared Duck *Malacorhynchos membranaceus*				4			4	126			3	2						
Grey Teal *Anas gibberifrons*	2	54	499	35	12	123	13	12	195	48	186	486	23	13	29	42	455	39
Chestnut Teal *Anas castanea*																		
Pacific Black Duck *Anas superciliosa*	4		23	66	6	19	8	12	4	12	2	8	4	28	51	2	34	27
Australasian Shoveler *Anas rhynchotis*			6	16	4	69	71	26		2	4	6	17					2
Hardhead *Aythya australis*						4	4		11					4		44	61	66
Australian Wood Duck *Chenonetta jubata*			6	32				2				54	6	5	25	2		8
Blue-billed Duck *Oxyura australis*						5	2											
Musk Duck *Biziura lobata*		1					1	2	2	1							2	5
Swamp Harrier *Circus approximans*											1					1	1	1
Buff-banded Rail *Rallus philippensis*												1						
Dusky Moorhen *Gallinura tenebrosa*										2		1						
Black-tailed Native-hen *G. ventralis*			2									35						
Purple Swamphen *Porphyrio porphyrio*	4	2	1		3	4			1	6	2	9			2			11

Eurasian Coot *Fulica atra*	18	2	235	27	412	55	94	513	45	35	65	11					25	4
White-headed Stilt *Himantopus leucocephalus*		13	45	68							5	2	22					2
Black Winged Stilt Himantopus himantopus															1	1	4	
Red-necked Avocet *Recurvirostra novaehollandiae*			18									2						
Masked Lapwing *Vanellus miles*		4	12	15					2	4	1	21	13		4		4	4
Banded Lapwing *Vanellus tricolor*														2				
Common Greenshank *Tringa nebularia*				1														
Red-capped Plover *Charadrius ruficapillus*																		
Black-fronted Plover *Charadrius melanops*			2	8					2		2	8		2			4	2
Red-kneed Dotterel *Erythrogonys cinctus*			3								2	9						
Sharp-tailed Sandpiper *Charadrius acuminata*																		
Silver Gull *Larus novaehollandiae*		2											5					
Whiskered Tern *Childonias hybridus*																		
Caspian Tern *Hydroprogne caspia*												3						
Lathams Snipe *Gallinago hardwickii*												1						

Date	**22-Oct-09**	**24-Nov-09**	**14-Dec-09**	**13-Jan-10**	**1-Feb-10**	**22-Mar-10**	**28-Feb-11**	**6-Apr-11**	**27-Apr-11**	**3-May-11**	**28-Jul-11**	**22-Aug-11**	**18-Nov-11**	**2-Feb-12**	**30-Mar-12**	**TOTAL**	**COUNT**
Australian Grebe *Tachybaptus nuovaehollandiae*	1										2			4	6	**197**	**26**
Hoary -Headed Grebe *Poliocephalus poliocephalus*																**540**	**18**
Australian Pelican *Pelecanus conspicillatus*	1		3	4	7									2	1	**654**	**35**
Great Cormorant *Phalacrocorax carbo*				2	1								4	71	6	**146**	**16**
Little Black Cormorant *Phalacrocorax sulcirostris*		45	7	4	45	15									23	**268**	**29**
Pied Cormorant *Phalacrocorax varius*															3	**10**	**3**
Little Pied Cormorant *Phalacrocorax melanoleucos*	4	2	3	4	12	1	4				1		1			**535**	**39**
Australian Darter *Anhinga novaehollandiae*			1			2							2	1		**33**	**16**
White-necked Heron *Ardea pacifica*		6	2	1									2			**23**	**11**
Great (Large) Egret *Egretta alba*	2	24	4	2	8								2	19		**165**	**28**
White-faced Heron *Egretta novaehollandiae*	2	2	5	2	8	1										**189**	**38**
Australian Ibis *Threskiornis molucca*	1	4	1	6				7								**198**	**25**
Straw-necked Ibis *Carphibis spinicollis*			1						4							**15**	**5**
Glossy Ibis *Plegadis falcinellus*	6															**40**	**2**
Royal Spoonbill *Platalea regia*				5												**21**	**7**
Yellow-billed Spoonbill *Platalea flavipes*	6	24	1	2	4									7		**188**	**27**
Black Swan *Cygnus atratus*	1	2			2	5										**790**	**39**
Freckled Duck *Stictonetta naevosa*																**128**	**5**

Australian Shelduck *Tadorna tadornoides*	8	5														**81**	**16**
Pink-eared Duck *Malacorhynchos membranaceus*					39											**614**	**9**
Grey Teal *Anas gibberifrons*	44	122	12	14		9	13						12	8		**4604**	**45**
Chestnut Teal *Anas castanea*																**4**	**2**
Pacific Black Duck *Anas superciliosa*	14	8			17				2							**674**	**37**
Australasian Shoveler *Anas rhynchotis*																**461**	**20**
Hardhead *Aythya australis*	46		1	4	2											**1178**	**24**
Australian Wood Duck *Chenonetta jubata*				5	2			9	4							**264**	**27**
Blue-billed Duck *Oxyura australis*	2		4													**13**	**4**
Musk Duck *Biziura lobata*							3									**34**	**15**
Swamp Harrier *Circus approximans*						1										**10**	**9**
Buff-banded Rail *Rallus philippensis*																**1**	**1**
Dusky Moorhen *Gallinura tenebrosa*								5								**14**	**6**
Black-tailed Native-hen *G. ventralis*	95								2				15			**219**	**10**
Purple Swamphen *Porphyrio porphyrio*	7												1			**81**	**24**
Eurasian Coot *Fulica atra*	9	33	7	5	22		4	2	12		1			6	2	**2574**	**40**
White-headed Stilt *Himantopus leucocephalus*																**263**	**13**
Black Winged Stilt Himantopus himantopus	13	2	5	9												**35**	**7**
Red-necked Avocet *Recurvirostra novaehollandiae*																**60**	**6**
Masked Lapwing *Vanellus miles*		4	2	6		4										**178**	**21**
Banded Lapwing *Vanellus tricolor*																**2**	**1**
Common Greenshank *Tringa nebularia*																**3**	**3**
Red-capped Plover *Charadrius ruficapillus*		1	1													**2**	**2**
Black-fronted Plover *Charadrius melanops*	2															**46**	**11**
Red-kneed Dotterel *Erythrogonys cinctus*	5												2			**110**	**8**
Sharp-tailed Sandpiper *Charadrius acuminata*																**5**	**1**
Silver Gull *Larus novaehollandiae*		2														**21**	**4**
Whiskered Tern *Childonias hybridus*																**14**	**1**
Caspian Tern *Hydroprogne caspia*																**6**	**3**
Lathams Snipe *Gallinago hardwickii*																**1**	**1**

Appendix E: Total abundance of waterbird functional groups recorded at Morgan CP. Functional groups include: Sh – Shorebirds; Du – Ducks, small grebes and jacanas; He – Herbivores; Pi – Piscivores; La – Large wading birds. Water levels are also included to indicate drawdown and refill phases of the wetland.



Appendix F: Fish monitoring data, Morgan CP, 2006-2011

		Survey date				
Common Name	**Scientific Name**	**Jan-06**	**Oct-06**	**Feb-10**	**Nov-10**	**Nov-11**
Australian smelt	*Retropinna semoni*		3 (5.37)			
Bony herring	*Nematalosa erebi*	56 (39.73)	2 (3.58)	29 (16.31)		8 (1.74)
Carp Gudgeon	*Hypseleotris spp.*	3064 (1445.49)	3986 (1834.90)	20 (21.82)	339 (70.90)	548 (77.59)
Common Carp	*Cyprinus carpio*	82 (38.70)		139 (41.82)	958 (150.65)	339 (48.09)
Dwarf flat-headed gudgeon	*Phylipnodon macrostomus*	3 (4.30)	4 (3.59)		1 (1.26)	
Eastern Gambusia	*Gambusia holbrooki*	187 (88.72)	250 (120.41)	2751 (833.81)	171 (35.96)	6 (3.24)
Flat-headed gudgeon	*Phylipnodon grandiceps*	11 (7.79)	1 (2.00)		8 (3.32)	12 (1.88)
Freshwater catfish	*Tandanus tandanus*					1 (0.99)
Golden perch	*Macquaria ambigua ambigua*					3 (1.59)
Goldfish	*Carassius auratus*			8 (9.14)	1 (1.25)	3 (1.89)
Redfin perch	*Perca fluviatilis*				2 (1.25)	8 (3.34)
Unspecked hardyhead	*Craterocephalus stercusmuscarum fulvus*	20 (13.83)	2 (3.89)	33 (18.05)	3 (1.89)	27 (6.20)

Appendix G: Frog monitoring data, Morgan CP.

Date	Site	Peron's Tree Frog - *Litoria peroni*	Southern Bell Frog - *Litoria raniformis*	Eastern Sign Bearing Froglet - *Crinia parinsignifera*	Common Froglet - *Crinia signifera*	Eastern Banjo Frog - *Limnodynastes dumerili*	Long Thumbed Frog - *Limnodynastes fletcheri*	Spotted Grass Frog - *Limnodynastes tasmaniensis*	Painted Frog - *Neobatrachus pitus*
Sep-05	**1**	Few	None	Lots	None	None	None	Few	None
	2	Few	Few	Lots	None	None	None	Many	None
	3	Few	Many	Lots	None	Many	None	Many	None
	4	Many	Few	Lots	None	Many	None	Lots	None
Dec-05	**1**	None	None	Few	None	None	None	None	None
	2	None	None	Few	Few	None	None	None	None
	3	Many	Few	None	None	None	None	None	None
	4	Few	None	Few	None	Few	None	Many	None
Dec-05	**1**	Many	Few	Many	None	Few	None	Many	None
	2	Lots	Lots	Many	None	None	None	Lots	None
Jan-06	**1**	Many	Many	Lots	None	Few	None	Few	None
	2	Lots	Many	Lots	None	Few	None	None	None
	Meeting Lagoon	Many	Many	None	None	None	None	Many	None
	Bird Lagoon	Many	Many	None	None	None	None	Many	None
Sep-06	**1**	None	None	Many	None	None	None	Few	None
	2	None	None	None	None	None	None	None	None
	3	None	None	Lots	None	None	None	Few	None
	4	None	Few	Lots	None	Few	None	Many	None
Nov-06	**1**	One	None	None	None	None	None	None	None
	2	None	None	None	None	None	None	None	None
	3	None	None	None	None	None	None	None	None
	4	None	None	One	None	None	None	None	None
Apr-09	**1**	None	None	Few	None	None	None	Many	None
	2	None	None	None	None	None	None	Many	None
	3	None	None	Few	None	Few	None	Many	None
	4	None	Few	Lots	None	None	None	Many	None
Sep-09	**1**	None	None	Many	None	Few	None	Many	None
	2	None	None	Many	None	Many	None	Many	None
	3	Few	Few	Many	None	Many	None	Many	None
	4	One	None	Lots	None	Many	None	Few	None
Nov-09	**1**	Few	None	Many	None	Few	None	Many	None
	2	Few	None	Many	None	Few	None	Many	None
	3	None	None	Many	None	None	None	Many	None
	4	None	Few	Many	None	Few	None	Many	None
Feb-10	**1**	Many	Many	Lots	None	Few	None	Many	None
	2	Many	None	Lots	None	Few	None	Many	None
	3	None	None	Many	None	Few	None	Few	None
	4	None	Few	Many	None	None	None	Many	None
Aug-10	**Meeting Lagoon**	None	None	None	None	None	None	None	None
	Bird Lagoon	None	None	Few	None	None	None	None	None
	2	None	None	Few	Few	Few	None	None	None
Sep-10	**1**	None	None	None	None	Few	None	Few	None
	2	None	None	None	None	None	None	None	None

	3	None	None	None	None	Few	None	Few	None
Nov-10	**1**	Few	None	Many	None	None	None	None	Few
	2	Few	Few	Many	None	None	None	None	None
	3	Few	Few	Many	None	None	None	None	None
	4	Few	None	None	None	None	None	None	None
Nov-10	**Meeting Lagoon**	None	None	None	None	None	None	None	None
	Bird Lagoon	Few	Few	None	None	None	None	None	None
Aug-10	**1**	None	Few	None	None	None	None	None	None
	2	None	Few	None	None	None	None	None	None
	3	None	Few	None	None	None	None	None	None
	4	None	None	None	None	None	None	None	None

Appendix H: ANZECC default water quality trigger values for south central Australia (South Australia)

Parameter	Trigger values and ranges		Reference
EC (µS/cm)	Lowland rivers	100-5000	ANZECC 2000
	Lakes, reservoirs and wetlands	300 -1000	ANZECC 2000
pH	Lowland river	6.5 – 9	ANZECC 2000
	Freshwater lakes and reservoirs	6.5 – 9	ANZECC 2000
	Wetlands	No data	ANZECC 2000
Turbidity (NTU)	Lowland river	1 – 50	ANZECC 2000
	Lakes, reservoirs and wetlands	1 – 100	ANZECC 2000
DO (mg/L)	Lowland river	90% saturation (> 6mg/L)	ANZECC 2000
	Freshwater lakes and reservoirs	90% saturation (> 6mg/L)	ANZECC 2000
	Wetlands	No data	ANZECC 2000
Temperature (°C)	Recreational waters	15 – 35	ANZECC 2000
	Aquatic organisms	6 – 30	DWE 2007